JOURNAL
OF THE
FRANKLIN INSTITUTE
OF THE STATE OF PENNSYLVANIA,
FOR THE PROMOTION OF THE MECHANIC ARTS.

VOL. CXXIX. MARCH, 1890. NO. 3.

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EMERY WHEELS.

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[*A Lecture delivered before the* FRANKLIN INSTITUTE, *December 9, 1889.*]

Mr. PARET was introduced by Prof. COLEMAN SELLERS, and spoke as follows:

MEMBERS OF THE INSTITUTE, LADIES AND GENTLEMEN:

The solid emery wheel is a modern invention.

Its enthusiastic makers claim that this wheel is a great labor-saving tool—that its use as a cutting instrument marks one of the great advances in the art of shaping metals.

The general public neither know nor care what an emery wheel is. The foreman is bewildered by inconsistent reports and complaints from his own shop, and hates the very name of emery wheel. The workman is stupefied by conflicting results, and distrusts both the wheel and its

maker. . The purchasing agent assumes that all wheels are of equal value, and buys the lowest priced. The salesman finds himself unable to get at the conditions of use, and compromises the wheelmaker by his shambling explanations. The publisher wonders at the advertising outlay of so unimportant an industry. The capitalist imagines that it must be larger than it seems, and backs up the first plausible scamp who claims that he has stolen his employer's secret. And the professional expert and educated mechanic wonder why the much vaunted virtue of the solid emery wheel is not demonstrated by figures and substantiated by data.

In the background stands the wheelmaker—the wheelmaker of established reputation and long experience. He did the pioneer work, and by his lavish advertising and enthusiastic claims built up not only his own trade but the whole general industry. He was condemned as an asker of extortionate prices in those early days when high price was so coupled with small trade and great expense as to shut out all possibility of profit. He saw competing goods sold for less than cost, and the insolvent makers started a second and third time in ruinous competition. He found mushroom factories backed by misled capitalists stocking up the dealers with low-priced goods and stuffing the users with bewildering and unsubstantiated claims. And, as the perfection and uniformity of his own goods increased—as widening experience in his own processes and in general shop practice slowly reduced his business to a science—he met a public which at last had lost all faith, and who believed there was no science in the industry. Who distrusted all emery-wheel makers—who distrusted even themselves, and who used goods they found to be a necessity without knowing which was the best make or what the proper use. Nevertheless he found through all this discouraging conflict of details such an increasing faith in the general utility of the solid emery wheel as a metal-shaping tool, as to produce a steadily growing demand. It remains now for the pioneer maker to establish the facts as to his much praised industry; to demonstrate by figures and substantiate by data;

to add to his own prejudiced enthusiasm the sober dictum of impartial men; to gain a consenting voice as to test conditions; to employ the skill of experts trained to the habit of exact observation. In a word, to establish, to the satisfaction of a mechanical public, the value of the solid emery wheel as compared with other cutting and shaping tools, and the comparative value of different wheels and wheel processes.

The general ignorance of this subject among those who do not use these tools seems due to a real lack of literature. Though devoted to this business for over twenty-two years, and eager to see all that has been printed concerning it, I find little of real value. Newspaper articles on the subject have generally been of a sketchy and popular nature, while essays and hand-book matter seem to have been compiled from the circulars and catalogues of emery wheel manufacturers.

The most comprehensive, thorough and exact treatise on this subject which I have seen, is a paper read on March 20, 1878, before the Society of Arts in London. The author and reader of this paper was Mr. Arthur H. Bateman, F.C.S., himself at that time perhaps the foremost manufacturer of solid emery wheels in Great Britain. I allude to this paper now because it is the only one I have seen which attempts to give the age of this still new industry. Mr. Bateman names 1842 as the birthday of the solid emery wheel. In that year, he says, "Henry Barclay patented a process for a solid emery wheel, using an equal part of Stourbridge clay and emery, pressing the wet mixture into moulds and subjecting it to a bright red heat." He says that owing to certain defects this process "does not appear to have been practically worked." He claims the invention, however, as British, and goes on to say: "It is satisfactory to know that the actual father of the modern emery wheel was an Englishman, although the development of the idea has certainly taken place on the other side of the Atlantic, and we are now appearing to be copying our American cousins in our tardy adoption of a *bona fide* English invention."

According to Mr. Bateman an attempt was made about

ten years later than the original patent to introduce solid emery wheels in the Woolwich Arsenal; while general attention began to be directed to the industry only five or six years previous to the speaker's address. At such time, he says there were many makers in America but only about four in England, while at the date of his paper the number in England had doubled.

From our own knowledge we will say that the industry, as a whole, has grown steadily and greatly, and that the number of manufacturers, notably on the Continent of Europe, has much increased. At the same time the whole number of wheel factories in all lands is not so great as might be expected. Most wheel factories are based on some special process, and if the process fails, the factory generally closes, having no other method to fall back on. Besides, the capital and the running expenses of this industry exceed expectation, and this discourages many who make a bold start. It is probable that at the present time there are not over twenty manufactories in the United States, and that not over one-fourth of these do an extensive trade.

My own connection with this industry dates back to 1867, and I can only remember three makes of wheels as existing at that time. Of these, two were at death's door, while one flourishes now. One of these was made by some use of the soluble silicates. I never knew what were the defects of the process, nor whether the failure of this make was due to pecuniary or practical causes. I suspect the latter. A second was made by mixing emery and melted brimstone. These wheels were used in the West, and, when drenched with water, had a certain value in gumming saws, though the general report was that they were very dangerous, as may well be imagined. I remember my first trial of one, dry. In a few seconds after I had pressed the end of an old file against the wheel a blue and suffocating smoke filled the shop. In a few seconds more the material became soft as putty and shoved up on the file. In a few more the matter burst into flame, and the wheel revolved in a Fourth-of-July blue blaze. The third was made of vulcanized rubber. This make still flourishes, and the difference between it and

the brimstone wheel indicates the correct line of progress. The brimstone wheel was brittle and easily affected by heat. The brittle material, brimstone, first mechanically mixed and then chemically combined with rubber, formed the new compound vulcanite—a substance much more elastic and cohesive and much less brittle than brimstone, while able to stand, unaltered, a much higher degree of heat. In this improvement is indicated that combination of qualities which is needed to make a good emery wheel. In the first place, such a wheel must have wonderful tenacity to withstand the centrifugal strain generated by its revolution at the speed of from three-fourths to one and three-fourths of a mile per minute. In the second place, its ability to resist heat must be great, inasmuch as the friction of grinding rapidly raises the metal being ground to a red and even an almost white heat.

Although not immediately evident, it follows from the above facts that the proper base for a perfect wheel should be some organic substance, either vegetable or animal.

It will be found that, as a rule, solid emery wheels can be ranged in three general classes: those entirely mineral, which are produced by some process of vitrifaction; those which are united by mineral cements, and are practically artificial stones; and those in which the emery is united with one or more substances of vegetable or animal origin.

The first solid emery wheel made (if Mr. Bateman is correct), that patented by Henry Barclay in 1842, was a vitrified wheel. This process failed at that time to come into practical use because, as Mr. Bateman says, "only small discs, say eight or nine inches in diameter, could be made, owing to the difficulty of avoiding cracks and distortion in the process of firing." Great progress has evidently been made in vitrifying processes since that time, and such processes seem to be particularly popular among the New England wheelmakers. Nevertheless, the early failure of the Barclay wheel indicates some of the defects which are still inherent in the vitrified processes. It may be safely said that brittleness is a grave defect characterizing all vitrified wheels, even the best, and that all are subject to hidden

defects, such as internal cracks and unequal tension. Another defect, whose cause is not obvious, is their tendency to glaze over and clog up with metal.

Although made by a totally different process, the artificial stone wheels seem marked by the same defects—brittleness, stony rigidity, hidden flaws, and the tendency to become brazed over with metal. Some of these have a fault not found in the vitrified wheel; that is to say, a tendency to deteriorate in quality; the mineral cements by which they are united altering on exposure to the air.

The third class—and that which seems to us made on better principles—embraces a great variety of substances. Among these the principal are glue, shellac, oxidized linseed oil, rubber, celluloid and tanite. It may be said of this whole class that it is much less liable to glaze with metal than are the other two; less liable to unsuspected and hidden defect; less brittle, and therefore more safe. It may also be said that, as a rule, wheels of this class wear out more quickly than do the vitrified and the stone wheels; and it is probable that their greater safety and their freedom from the tendency to glaze are due to their rapidity of wear. In this third class is to be found a wide range of quality, while the class can be broken into two divisions. One comprehends those wheels whose quality is due to some more or less heterogeneous mixture or combination, and the other those which owe their peculiarity to the distinctive quality of some unique substance. The first class includes much varied mechanical mixtures of gums and glues with oils, ashes, lime, blood, albumen, flours, etc., etc. The second class includes unique substances—chemical products such as the oxidized and vulcanized oils and gums; metamorphosed woody fibre, such as celluloid; and tanite. Of all these except the last the qualities are well known. Of the latter little can be said (its manufacture being a trade secret) except that it is a metamorphosed leather.

For all of these varieties special advantages are claimed by the makers, but their real comparative value has yet to be demonstrated by prolonged investigation of such character as to afford exact data regarding the safety, uniformity and economy of each make.

It should be said here that many of the popular notions on these subjects are based on insufficient data, and that the easily observed facts in the use of solid emery wheels are singularly misleading.

Of that material which is most important in all solid wheels—that is to say, the emery—only brief mention can be made here. The subject demands a whole lecture and would probably be more fascinating than our present theme.

Formerly, though the emery ore or stone came mostly from Turkey, the emery was about equally well known under the name of Turkish and English. England imported the great bulk of the ore, and was the great exporter of grain or manufactured emery. I well remember that, misled by this fact, in the greenest days of my early start in this industry, I sought and bought only that emery which bore the brand of "Best London." I discovered later that it was manufactured less than fifty miles from New York. The Turkish ore came from the neighborhood of Ephesus, in Asia Minor, and being shipped from Smyrna was called by that name, while Greek emery, of which there was a less supply, went by the name of Naxos. At one time the greater part of all the emery used in America was imported from England, but for many years several mills have been crushing ore in the United States, and the industry is now a well established and successful one.

For the decade ending with 1878, our average annual import of emery ore was 2,376,743 pounds. For the decade ending with 1888, it was 7,315,165 pounds, the year 1888 showing the largest total of any year but one during twenty years. That total was 9,643,800 pounds. While the annual import of ore was more than tripled in the second decade, the annual average import of granulated and pulverized emery slightly decreased. That annual average import was for the first decade 621,807 pounds, and for the last 589,054 pounds. The total annual average import of ore and grain for the first decade was 1,338 tons, and for the second 3,521 tons.

Two unsuccessful attempts were made in years past to popularize emery made from American ores, but we cannot

find that any effort has been made to work emery mines, except in Turkey, Greece and America. During late years corundum has come into notice as a competitor with emery, and enormous superiority has been claimed for it. To such superiority, especially when used in solid wheels, the United States Government has been made a deluded witness.

In its report, for the years 1883 and 1884, upon the Mineral Resources of the United States, the corundum product of the South was treated. Unfortunately, the expert who was employed was not an expert on solid wheels, and the matter supplied as fact is far better calculated to keep up a fictitious price on corundum than to convey correct information. It seems doubtful if the assertions made were based on any actual experience or carefully acquired information as to the manufacture and use of grinding wheels.

On this subject the impartial testimony of Mr. Bateman should be given. He says: "For certain purposes, where it is possible to run in a constant stream of water, corundum wheels appear superior to emery; but for the general run of engineers' work, which is certainly on the whole done best dry, for tool grinding, and, indeed, most other purposes, our English experience is so far vastly in favor of emery over corundum wheels."

In my own experience of twenty-two years I have seen no demonstration of the superiority of corundum.

This mineral is found principally in the mountain regions of North and South Carolina, Georgia and Tennessee. While constant discoveries of it are being made in this general region, it is seldom found in large quantity. That put upon the market thus far has been procured at considerable expense, at a great distance from railroads, and has been sold at a price about three times that asked for emery.

The Government Reports on the Mineral Resources of the United States give the corundum product of 1886 as 645 tons and that of 1887 as 636 tons. No mention is made of the product previous to 1886. While the occurrence of this mineral is not rare, the manner in which it occurs is such as to make the amount and continuousness of the supply very doubtful.

The price of emery ore varies, according to the mines from which it comes, and even according to the size of the lumps. It is a matter of grave doubt as to how far price is an indication of quality. The same doubt affects all questions connected with supposed variations of quality in the manufactured emery. Great stress is laid by different makers upon the quality found in ores from special mines—in the hardness of the mineral—in the artificial shape of the grain produced by various mechanical processes, and even in the color. A very general impression seems to be that the one distinctive quality of emery is its great hardness, and that as this is due to the alumina (the iron combined or mixed with it being considered an adulterant) the greater the proportion of alumina the better the emery. If this were so the chemist's analysis would be a simple and accurate way of establishing the comparative value of ores. My own belief is that we do not yet know why one mineral grinds well and another ill. That while certain facts, such as hardness and external form, are indications of value, there is a varying grinding capacity in different minerals whose cause is by no means obvious.

The manufacture of emery is simple. The ore is broken in the ordinary stone crusher, then still further reduced in size by being passed through rolls or under a stamp mill, and then assorted by being sifted through wire cloth. When ready for market it is numbered according to the mesh of the wire cloth through which it has passed. To be clean—that is, free from fine dust—and to be uniform in size—are the principal things to be desired.

The coarsest emery is that which goes through a wire cloth of five meshes to the inch, and the finest numbered emery 160. It is also used in fine flour. In the early days of the emery wheel industry (when the buyer knew more than the seller) the buyer dictated most arbitrarily as to his needs. In those days solid wheels were called for from five to flour. In later days (when the seller began to know more than the buyer), the seller greatly reduced the variety of his goods. It seems probable, even, that the greatest impetus given to the trade was due to the action of one concern

which suddenly reduced its variety from ninety-six qualities or grades to five, which refused to say what kind or what size of emery it used, and which simply offered specific goods for specific purposes. This lead was speedily followed by most of the makers in different countries, and to the simplification thus caused is due much of the emery wheel's later success.

As a result of this change, less coarse emery is used in solid wheels than formerly, and very much less fine. It was found in practice that the small difference in the size of emery, as it varied by number, was not accompanied by a corresponding difference in the cut. In fact, it appeared that the increasing fineness of cut, due to increasing fineness of emery, finally reached a point at which it was neutralized by lines and wave marks, due to the vibration and chatter of work and wheel. This fact soon proved an eminently practical one, and indicated one limitation of the new industry.

Put forward as a competitor of the file, cold chisel, lathe, planer, milling machine, grindstone and wood and leather or buff wheel, it was mistakenly asked to supersede all these. The most enlightened soon found that it was not the work of a solid wheel to polish. Something more was needed than mere fineness, and that something was the compressible or yielding quality which is admirably supplied in the thick, spongy sea-horse or walrus leather which is often used to cover a wooden wheel, and which is approximated to by other qualities.

To meet this want, which the solid wheel of rigid hardness failed to fill, the attempt was made by one concern to introduce a so-called semi-hard wheel. It was found that in such a wheel emery of a given number did much finer cutting than did the same emery in a rigid wheel. But it was also found that, owing to the elasticity of the semi-hard wheel, it stretched and expanded under the centrifugal strain. This thinned it at the centre, so that the flanges which clamped it on the machine spindle failed to hold it, and by the continued screwing up of these flanges, and the continued stretch, the wheel was at last burst. At half

speed, which proved safe in practice, this wheel was a moderate success; but buyers would not so use it, and, therefore, it was withdrawn.

It follows from this that the proper duty of the solid wheel is not to polish, but to grind.

Having thus explained why the solid wheel does not supersede the wood and leather wheel, I may be asked why it does not supersede the grindstone.

This is, perhaps, partly due to an intense conservatism. Until very recently, England was the great producer of ground and polished goods, and Sheffield the headquarters of the grinding business. In his fascinating novel, *Put Yourself in His Place*, Charles Reade illustrates most graphically the tyranny of the Grinders' Union and the danger of the grinders' trade. It may easily be imagined what a barrier to progress would be found in such a union. It may also be imagined that a workman, who is selected on account of his weight, and who draws extra pay because he straddles a board over a dangerous grindstone and works in a slop under unhealthy conditions, will object to the removal of the danger and the slop.

It has become a custom to use grindstones of very large size, and wet, for certain uses. It seems doubtful, whether in all cases, either size or wetness, is a necessity. If it is, water-proof wheels could be supplied of the desired size. Thus far, however, neither the wheelmaker nor the grindstone user seem willing to risk so costly an experiment. It seems too great and too radical a reform to be quickly accomplished. It is a little singular, however, that European users, who, as Mr. Bateman says, seem to be copying the Americans in their adoption of this industry, should now be rather leading us in the use of large wheels. The use of wheels, 36 inches in diameter by 4 and by 8 inches in thickness, is not an uncommon one abroad, while, so far as our own experience goes, such use is very limited here.

As a strict competitor of the lathe, planer and milling machine, the application of the solid emery wheel is somewhat proportioned to its use as a substitute on such machines for the steel tool usually employed. Its value, as

compared with that of the steel tool, is partially dependent on that hardness which enables it to easily cut the hardest steel, chilled iron, case-hardened surfaces, and the most resistant substances known. It is also due to the greater perfection of its product. The steel tool presents only a point or narrow edge. The tool is liable to deflection and wears with comparative rapidity, while the abrasive force of the metal being ground on a solid wheel is spread over a great superficial area. Thus, in an emery wheel, 12 x 1, there would be over thirty-six square inches of cutting surface. Hence, spindles, such as are used in sewing machines, etc., after being turned approximately true in a lathe by means of a steel tool, can be perfectly fitted to a gauge ring by means of the grinding wheel. Hence, the ability to supply stacks of calender rolls of such perfect diameter and with such absolute lines as to be interchangeable in all combinations. In the lathe and planer we have a cutting point whose hardness is but slightly greater than that of many of the materials it has to cut. In the solid wheel we have a myriad cutting points vastly exceeding in hardness any material they are called upon to grind. In the milling machine we have a rotary cutting tool running at low speed —in the solid wheel a very high speed.

If the solid wheel has not proved a more formidable competitor of the steel tool in lathe, planer and milling machine work, it is mainly because the same amount of ingenuity and money have not been expended in applying the wheel; and this is natural when the youth of the industry is considered. At first the wheelmaker left the buyer to mount the wheels as he would, and the crudeness of the mounting was sometimes equalled by the crudeness of the wheel. I once saw some foreign wheels which absolutely lacked a spindle hole, being simply discs, so irregular as to suggest that they had been moulded in the battered cover of a tin can. As to the early mountings a rough wooden frame answered. To extend their trade the wheelmakers began to manufacture machines, confining themselves at first to simple machines for general work, and even yet but slowly branching out into special lines. But, as Mr. Bate-

man well says, "if an elaborate and expensive machine is required to actuate and utilize a simple point, it is equally required for this revolving file."

The manufacture of machines wherewith to apply solid wheels is yet in its infancy.

Apart from their use for shaping metals to exact dimensions, the lathe, planer and milling machine are often used merely to remove metal. In such use the solid wheel, mounted on simple, general machines, is a competitor of importance.

Thus far the grinding process has been compared with processes similar in one respect, inasmuch as in every case the cutting tool was attached to a fixed machine and the work carried to machine and tool. In the file and cold chisel are found cutting tools whose peculiarity is that they are carried to the work. Evidently in some cases this is a necessity. To meet this need some advances have already been made in the application of the wheel. It has been so mounted as to have a wide range of vertical and horizontal motion, and the dentist's use of the flexible wire cord to revolve a grinding wheel between the teeth illustrates in a small way the possibility of carrying such a wheel to its work.

In a great part of the duty done by file and cold chisel those tools are not carried to the work. They are used at the bench, with the vise as their necessary and expensive companion. Apart from all considerations as to the relative capacity of the different cutting tools, the necessary use of the vise lessens enormously the product of file and cold chisel. Especially is this true when many pieces have to be operated on. Each piece has to be clamped and unclamped at least once, and possibly several times. This time is an absolute loss which should be devoted to the removal of metal.

To establish on good authority the superiority of the solid wheel to the file we contrast the filemaker's caution as to the use of files with the wheelmaker's comments thereon.

The following remarks are quoted literally from the catalogue of a well-known file manufacturing house:

A FEW WORDS ABOUT USE OF FILES.

"A new file should always be used with a light pressure on the work till the needle-like points of the teeth are worn away; after this, a much heavier pressure may be used with much less danger of breaking off the teeth at their base. Many new files are violently diminished half their efficiency by a few careless strokes when first applied to the work.

"Do not use a new file on the chilled and gritty skin of castings, or on a weld where borax or any vitreous fluxes have been employed. No file can endure such usage.

"Every filer should be required to keep a worn file with which first to attack the rough, gritty or oxidized surface of iron work, and thereby pave the way for a more efficient work with his sharp files. A piece of gritty or chilled casting that would rapidly destroy the cutting qualities of a new file would produce scarcely any damaging effect to a worn one."

The answer to this caution is taken from the circular of a well-known wheelmaker:

"Each grain of emery is a compound crystal, and the pressure which breaks down or wears off the external crystals only uncovers internal ones. Each emery wheel is a compound, as it is a series of concentric rings of cutting points from the ring on its outermost face to that nearest its centre. The pressure which breaks down and wears out the outermost layer of emery grains only uncovers a new layer. Therefore its cutting points can neither be dulled nor destroyed. Your workman may dawdle away his valuable time over a valueless file, but the running-wheel cuts freshly to the last.

"You can use the solid wheel, whether new or old, on 'the chilled and gritty skin of castings,' and 'on welds where borax or any vitreous fluxes have been employed.'

"The Blank Company's machinists grind off the corners of their pulleys, so they can enter their lathe tools under the scale."

Much the same objections apply to the cold chisel as to the file. The cold chisel is easily damaged by a few careless blows, and, requiring the use of one hand for the

hammer, can be only imperfectly guided with the other. Like the file, its efficiency steadily decreases, while the force needed to drive it increases. Both are tools whose manifest characteristic is that they steadily employ the worker in such a way that his apparent activity is no indication as to the usefulness of his work. Both are tools much to the taste of lazy workmen and of boys.

It may be objected that the solid wheel, also, is a tool which steadily decreases in efficiency—that its first cut is its best, and that it so glazes and clogs up with metal as to grow duller and duller. The answer to this is that the objection only holds true of poor wheels—that a wheel of the right make, rightly selected and rightly run will not grow dull, but will maintain its efficiency to the last.

In Mr. Bateman's paper of 1878, he enumerates fifty distinct applications of the solid wheel. We think it useless to even attempt such an enumeration now, and prefer to select some of the most important or striking applications. It is enough to say, as explanatory of the wheel's manifold uses, that wherever wood or metal are worked, the wheel can be used to advantage, not only directly to work such wood and metal, but to maintain in their full efficiency the tools which are in common use for working wood and metal. Saws of all kinds, moulding bits, and planer knives are all kept in order by the use of solid wheels.

In old times the saw had to be sent for repairs to some sawmaker at a distance. As time and freight charges were important the number of such sendings was limited. As a result the saw was sent back with its teeth too long for full efficiency, and was retained in use again till worn too short. By the use of the solid wheel, in the saw mill itself, saws are now maintained at their full efficiency. In many cases the wheel is only used to gum (or as the English say, gullet) the saw, while the cutting edge is put on with the file. But by appropriate machinery the whole can be done by the wheel. Conflicting statements are made as to wheels cracking, case-hardening and drawing the temper out of saws. The fact is that it is all a matter of practice. The wheel user can create as much or little heat as he chooses,

and adroitly adapt himself to any desired condition. I visited many years ago an establishment in this city where bung-boring tools were made, and was sarcastically offered a tempering furnace—cheap. After many elaborate efforts at tempering it had been discovered that the best result was secured by bringing the knife to a certain heat in the process of grinding, and simply throwing it on the table to cool.

A lumber manufacturer, also of this city, told me he always had his saws ground by the wheel to the desired bevel and purposely case-hardened, so that the file could not touch them. He claimed that in this condition they would cut thirty-three and one-third per cent. more lumber without re-sharpening than if they had been left soft enough to file. The complaint as to cracking of saws we believe to be unfounded. As to the case-hardening, a light touch with the wheel, after the saw is cooled, will instantly remove it. We have been applied to within the last few weeks for saw-gumming wheels, which were to be of such quality that they would glaze up and only cut a minimum. These were for use on slate saws, and the customer's claim was that the saws could be tempered by the use of what, for ordinary purposes, is an almost useless wheel. Of late years, automatic saw-sharpening machines have come into use, principally in the West.

Planer knives and moulding bits, like saws, are often used when not in their most efficient state. By frequent use of the solid wheel the edges can easily be kept sharp, and the bevel at its proper angle. The automatic knife-grinding machine is an unqualified success. This is used, not only for the long knives of wood planers, but for veneer, leather and paper knives. One advantage of this machine is the perfection with which it grinds a long, straight edge. As a matter of curiosity, we note the case of a Manchester manufacturer, who used one of these machines to grind the knives with which he raised and cut the thread of cotton cloth. His product was lint and a velvet-faced cloth for coffin linings. He claimed that his whole success was due to the perfection of the knife grinding, and refused all inspection of the machine, even to its maker.

The solid wheel is largely used to shape and sharpen metal-working tools. For this purpose the wheel is used, simply mounted, as a substitute for the grindstone, and, by special machines, is fitted for grinding of exact angles on milling cutters, twist drills and lathe and planer tools. A word should be said as to the use of wet or dry wheels for this purpose.

The original use of water on solid wheels was evidently copied from grindstone practice or due to the fact that the wheel itself (as, for instance, the brimstone wheel) could not stand heat. As the quality of the solid wheel improved the use of water began to die out, for the best wheelmakers advocated the use, at high speed, of soft, free-cutting wheels, to be worked with a light touch. Of late years a reaction has set in, and tool grinders for wet grinding are being extensively advertised. In our opinion the reaction is most unwise. If a light touch and soft wheel are used, the metal can be cut so freely as to generate little heat. That little can be lessened by dipping the tool in water, or by a slight drip upon it. But when water is freely used it acts as a lubricant and diminishes the cut, so requiring greater pressure and producing greater heat. Besides, much harder wheels are generally used, and greater pressure required than in the case of the soft, dry wheel.

The direct use of the wheel on wood is limited. Soft substances tend to clog the solid wheel, and but little progress has been made in its adaptation to such substances. In fact, little attempt has been made. Efforts have been made to grind leather boot heels and raw hide hinges, and not infrequent demands are made for wheels to grind cigar boxes. This is because the box is a combination of wood and nails. Frequent demands were made a few years ago for solid wheels of large size to take the place of grindstones in the manufacture of wood pulp. We are not able to say, however, whether they were a practical success.

The direct applications of the wheel for metal working are innumerable. We have already alluded to the perfecting work done on calender rolls and spindles. Of like character is the work done on plane surfaces by the surfacing

machine. In this machine the top of the solid wheel is set in the same plane as that of a table, and the metal being passed over the wheel and table, has its convexities removed. Small machines of this character are used for many purposes, while large ones, with tables seven feet long, are used for grinding locomotive guides.

A large and steadily increasing demand for the solid wheel depends upon the increasing use of chilled iron and very hard steel. The grinding of chilled car wheels is a steadily growing practice. Such wheels, made by the old processes, are rarely centred properly. If the axle, having the wheels forced on, is run into a grinding lathe, the solid wheel does its perfecting work, and a wheel of correct diameter, evenly centred, is the result. But the wider use of this process is for re-grinding worn wheels. Old wheels get out of round, and, on heavy grades, new wheels are often quickly flattened. Too hard to be turned with a steel tool, the old plan was to take the axle to a hydraulic press, press off the old wheels, to be thrown in the waste heap, and force on new ones. Now the axle is run into a grinding lathe and the ground wheels after making a mileage equal to that of the new wheels, are sometimes ground a second time.

The use of the emery planer on steel dies is a most important one, though too little appreciated. As the edges of a solid die became nicked and frayed the sides of the blank became more grooved and furrowed. The die was too hard to be planed down unless it was untempered and re-tempered. But the solid wheel will rapidly plane off the surface of the hardest die, and as a result we have nuts of a lessened weight, and with sides so smooth that finishing is reduced to a minimum.

Great use is made of the solid wheel for jointing plow shares—a use specially hard, as such shares are often composed of a central sheet of soft metal, overlaid and underlaid with the hardest steel.

The surfaces of chilled plows are also ground with solid wheels. In all branches of the agricultural implement manufacture such wheels are largely used.

The manufacture of fire-proof safes calls for many solid

wheels. These wheels are sometimes hung in a swinging frame and passed over the safe, after it has been put together, in order to level the bolt and rivet-heads.

As wheels are made from three-eighths of an inch in diameter, and weighing only a fraction of an ounce, to those which measure thirty-six inches in diameter and weigh 800 pounds, it can readily be seen that it is impossible even to enumerate the various uses of the solid grinding wheel.

This wheel is called upon sometimes to grind material harder than metal. They have been regularly used for many years in the manufacture of encaustic tiles, and a new use is but now springing up for them in silk factories.

I hold in my hand a glass guide such as is used in the hard silk or throwing departments of silk mills. These are used in the processes of winding, spinning, doubling, twisting and reeling. From 25,000 to 30,000 of these guides, costing about eight cents each, are used in the one silk mill in my own town. At the end of three years these guides have worn to such an extent as to be greatly impaired. The wear is greatest in the winding department. Solid wheels have recently been introduced, and these guides are now being ground at the rate of five per minute, the belief being that they will wear longer after being ground than before. Owing to the tendency of the glass to crack when heated water-proof wheels are used and the process of wet grinding adopted. It seems astonishing that the soft silk should cut glass; but the magnifying glass shows a deep and tapering groove of such character as eventually to break the threads.

It is gratifying to know that the superiority which Mr. Bateman conceded to the American emery wheel in 1878 still exists. At that time Mr. Bateman spoke of America as "the natural home" of the solid emery wheel, and named one American make as having "long enjoyed the reputation of being the standard wheel." Speaking of the European continent he said, "besides imported wheels there are several local makes of varying degrees of merit, but mostly cheap (or rather low-priced), and with greatly less cutting power than English and American wheels." At the present time American emery wheels have a high reputation

abroad, and despite duties and low prices are exported widely. A steady demand for them exists in France, Belgium, England, Holland, Denmark, Norway, Sweden and Finland, while occasional orders come from the other continental countries. Australia is a large and steady consumer, while New Zealand, South Africa, China and Japan are occasional buyers. A trade is also growing up slowly in South America.

It is not probable that any other tool or process will take the place of the solid emery wheel, and the demand for it is likely to increase as the manufacture of wood and metal does. It is possible, also, that the trade may be extended by its application for new uses. Many years ago there was great inquiry for solid wheels and solid emery composition in connection with the manufacture of cereals. Thousands of dollars were spent in this country in the attempt to devise machines for pearling grain—that is to say, for stripping it of its outer husk. Abroad somewhat similar experiments were made with rice. As a rule elaborate and costly machines were entirely finished before the emery-wheel maker was consulted, and their failure was often due to such lack of consultation. It is worthy of remark here that the success of the Hungarian or roller process of making flour is partly due to the use of the solid emery wheel by which the chilled rolls are kept in order. It is quite probable that successful applications may yet be made in this industry. In fact one of the problems of the future is the substitution of emery for burr stone grit in the making of millstones. Not only might such stones prove vastly more durable, but also keep sharper.

In addition to the possible use of such emery millstones for use on cereals, their great hardness would fit them for use in the crushing of the most resistant ores and minerals.

In their application to metal grinding we think there are to be large advances. One such advance would be in their general adaptation for use on the ordinary iron planer. One objection to the use of solid emery wheels in the machine shop is that the dust is destructive. Where this objection cannot be met by the introduction of suction fans and the

removal of dust, suitable grinding-rooms should be provided, and grinding lathes and planers supplied. While the adaptation of the wheel to the common lathe and planer would be a great economy, special lathes and planers should also be devised. There is reason to believe that pulley grinding would be a great success. Machines have been built for this purpose, but as yet too little has been done in this direction.

A machine most successfully used in Great Britain does not seem to have been introduced here at all. That is an automatic wheel tooth cleaning machine, in which the solid wheel grinds between the cogs.

We saw the grinding lathe used in Lancashire over ten years ago for finishing the face and sides of the cog wheels used in textile machinery. We have seen no such use here.

An important extension of this industry is yet to be made in the wider use of the solid wheel for grinding and fitting long edges. So long ago as 1874, one of the largest manufacturers of architectural iron work in New York mitred and jointed his work this way so perfectly that no other fitting was needed, and had built an emery grinder for this purpose, for whose running he proposed to put in a special steam engine. The edging and bevelling of boiler plate is also likely to be a thing of the future.

But the greatest extension in the demand for solid wheels should arise from a recognition of their value as the great metal removers. A professor of mechanics, who visited a grinding-room recently, characterized it as "a cast-iron slaughter-house." Nevertheless, in the technical machine shop, presided over by this professor, the students were provided with bench-room and nine vises, but only one grinding machine. It is only natural that the uneducated mechanic should undervalue the solid emery wheel when those who graduate from a mechanical college are unacquainted with the value of the wheel as compared with other cutting tools. It is equally natural that the technical school should not demonstrate that value, for its work is largely a reaction from the practical problems which are presented to it.

So great and sudden has been the demand for men trained for the duties created by the introduction of electricity, by the extension of steam transit over land and sea, and by the introduction of new forms of metal, that there is some danger of neglect to the so-called simpler processes of mechanical work. It is a more tempting thing to the student to build a railroad bridge, to set up an electric plant, to gain an hour on the ocean ferry, to make a new alloy or invent a new steel process, than to perfect some crude method of common, every-day work, or elaborate a great economy from a small industry.

The small industry has not, as yet, cried aloud to the student to learn or the professor to teach, and it cannot justly upbraid them.

It still remains for the emery-wheel maker and builder of grinding machines to lift this new industry out of the realm of doubt, and establish by facts and figures the value of the process.

We have now summarized in simple language the history of this new art. We have briefly explained the nature of the crude materials. We have suggested certain great, inherent differences in various makes of solid wheels. We have roughly compared the emery wheel with the steel tool. We have sketched the main features of the wheel's application by special and by general machines. We have outlined the probable development of the business.

Thus far, he who runs can read.

We have now to show by closer reasoning, and by facts and figures more difficult to comprehend, why absolute demonstration has been so long delayed—to give such demonstration as is now possible, and to indicate the methods by which fuller demonstration is yet to be attained.

The variety of uses to which solid wheels is put is so large that no wheelmaker can possibly attempt them in his own works. The wheelmaker's experience includes the results of his own general and special uses in his own works —his immediate observation in the works of others, and the accumulated correspondence of manifold users in the most

varied branches of manufacture. Unfortunately, no branch uses wheels so largely as to make them an obviously important subject. They are mostly used by ordinary laboring men, who are not interested in the nice questions of practice or economy, while the educated mechanics of the establishment have problems of apparently greater importance to engross their attention. We know of but one large concern which has kept for years an exact record of every wheel used, and while we have seen this record, we have not been allowed to use it. In some of the factories where we have most desired to study the working of solid wheels, we have been denied all access. As a general thing, the conditions of use are not known to the wheelmaker and are often such as he disapproves.

The first and most striking characteristic of the solid emery wheel is its enormous speed. By common consent the speed of about one mile in a minute for a point on the circumference of the wheel has been adopted. At one time some makers, doubtful of their wheel's strength, advertised that their wheels would do full work at half speed. These have since increased their speeds. One concern, finding itself safe at a high speed, has very recently advanced such speed to nearly two miles per minute. A wild theorist, many years ago, assumed that a wheel's cut increased in direct proportion with its speed, and tried to induce Sir William Armstrong, the great English gunmaker, to erect grinding machines on massive foundations, with wheels running at phenomenal speeds, and so banded with steel as to make bursting impossible.

The fact really is that the data do not exist to establish the best speed. Limited experiment tends to show that the recent increase from a mile to nearly two miles is accompanied by an increased cut, but that the result is extravagant in cost inasmuch as the wear of the wheel increases out of all proportion to that of the metal. It should be remarked that very few wheels can be safely run at such a speed. On the other hand, a too low speed results in decreased cut of metal and increased wear of wheel. The broad, general claims of the wheelmaker are based on the

high speed. Hence, those whose work calls only for small wheels are often disappointed in the result. The speed of a thirty-six-inch wheel is 611 revolutions per minute. To give the same surface speed a one and one-half-inch wheel would have to be speeded at 14,400. As a rule, therefore, very small wheels are run below the standard speed, and accomplish less than average work.

Running at the standard speed the solid emery wheel is equivalent to a file one mile in length, passing over the metal in one minute. The hand used tool of ordinary work at the vise bench is equivalent to a file only sixty feet in length, passing over the work in one minute. To make this comparison strictly true, the metal and the wheel must be in continuous contact for the minute. This necessary condition, apparently of general occurrence, and to be secured in the simplest manner, is really seldom found and is most difficult to secure. Even lathe-turned emery wheels are not always perfectly round. It is by no means an easy task to centre them perfectly upon the grinding machine, and many workmen do not centre them at all. The hole apparently fits the spindle (though it generally is and always should be too large), and they trust to that. The wheel is started, the iron melts away visibly, a comet-tail of sparks flashes across the shop. The boy who whirls round his head a smouldering fire-cracker at the end of a string does not imagine that he owns a continuous and circular fire-cracker. The man who sees a continuous stream of sparks fly from the emery wheel does delude himself with the idea that he has a tool which is continuously at work. Such a man is surprised when an expert stops the machine and shows him that his wheel is hot and glazed for perhaps one-fourth of its circumference, but cold and apparently untouched for three-fourths. That, in fact, he has utilized only twenty-five per cent. of the wheel's possibilities. What are the causes of this? We have indicated a few evident ones. Possibly the wheel was not round to start with. Possibly it was not properly centred. But there are some causes not so evident and still a matter of doubt. Possibly the wheel material is not absolutely homogeneous, and

expands unequally under frictional heat. Possibly, owing to the same lack of homogeneity, the metal adhered to and glazes one part rather than another. Possibly, owing to the light weight of the machine and the unsteadiness of floors, an irregularly regular vibration is set up, and the wheel and work part contact rhythmically. All these causes may combine. Undoubtedly the high spot formed by adhering metal shoves back the piece being ground, and a large wheel surface revolves unused before work and wheel are again in contact. The remedy is to use those makes of wheel which glaze the least, for glazing, by making high spots on the wheel, prevents all possibility of continuous contact and steady work. The solid emery wheel is a rotary file, which runs a mile in a minute, and whose cutting points never grow dull. This is said only of the perfect wheel, though glazing is one way in which the points may be dulled. In experimenting with many makes of wheel a curious difference is seen in their tendency to glaze. In some the metal adheres to all parts of the surface and finally becomes a continuous brazed ring. In others the metal gathers in patches. Certain makes, however, may be considered practically free from these faults under all general conditions, a slight shininess of surface being the visible indication, while deterioration of cut is manifested only under very light pressures.

In an article in the *Scientific American Supplement*, for April 24, 1886, No. 538, your present speaker contrasted British and American usages as to the weight of grinding machines, showing that the British put 577 pounds of metal into a machine designed for twelve-inch wheels, while an American machine for the same purpose only contained forty pounds. In a subsequent article, published in the *Railroad Gazette* of May 27, 1887, he gave results obtained by the use of a fourteen-inch wheel on a 662-pound machine, such machine being mounted upon and fastened to a mass of stone and concrete. In a still later article in the same journal, under date of February 15, 1889, he compared and illustrated the cut made by an average wheel imperfectly mounted with that made by a free-cutting wheel solidly mounted.

This contrast will be made visible at the close of our lecture by means of the magic lantern.

To obtain the maximum result from any emery wheel, it must be perfectly round, perfectly centred, must be run at a high rate of speed, and be so solidly mounted and so free from adhering metal as to allow of continuous contact between work and wheel.

Under such conditions, what can be expected? That depends on the size of the wheel. With equal speed and proportional pressure a wheel six inches thick ought to cut off six times as much metal from a bar six inches wide as a wheel one inch thick would from a one-inch bar. Manifestly we cannot say what the emery wheel will do as compared with the file but only what some specific wheel will do.

The article already referred to (in *Railroad Gazette* of May 27, 1887,) contains a mass of interesting statistics which we can only summarize here. The experiments were made with only one make of wheel, the size being about 14 by $1\frac{3}{4}$ inches. In comparing the cost of various processes the same rate for labor was charged against wheel, file and cold chisel. Charging a moderate price for the wheel (thirty-three and one-third per cent. discount from list) the maximum cost of grinding off one pound of cast iron was eleven and three-fifth cents. Charging a low price (sixty per cent. discount from list) the minimum cost was two and four-tenths cents. The cost per pound of filing off cast iron was thirty-five and nine-tenths cents.

As the wear of file, hammer and chisel were not certainly ascertained, and as steam-power was not counted in the cost of grinding, objection may be made to all the cost tables. We prefer, therefore, to omit these, and confine our statements to the relative products. In one-half hour's steady work the emery wheel removed seventeen pounds of brass, the cold chisel one pound and four and one-half ounces, and the file only eight ounces. The wheel removed seven pounds and twelve ounces of cast iron, the cold chisel two pounds and five and one-half ounces, and the file only five and three-fourth ounces. The wheel removed two pounds and eight ounces of wrought iron, the cold chisel ten and

one-half ounces, and the file two and three-quarter ounces. The wheel removed three pounds and seven ounces of saw steel, the cold chisel one and one-half ounces, the file only one ounce.

Remark here, in the extraordinary results with brass and saw steel, the peculiarity of the emery wheel as compared with the steel tools. The soft metal clogged the file and reduced its cut so that the wheel removed thirty-four times as much as the file did. The hard saw steel resisted the file so that the wheel removed fifty-five times as much as the file did. Cast iron, which neither clogged much nor resisted greatly, gave the file greater play, and the wheel only removed about twenty-one times as much as the file.

We say only twenty-one times as much! But bear in mind that none of these results are the maximum ones, but were obtained with a wheel supposed to be only an average cutter. We illustrate hereafter the case in which a wheel removed in equal time 126 times as much as the file.

Valuable as these results are, they only point the way to methods by which in the future we hope to ascertain facts of still greater value. It does not follow that the wheels with which these experiments were made were the most economical ones, or that they were used in the most economical way. In all of these experiments the work was forced against the wheel by hand, and such experiments gave but uncertain results owing to the inequality of pressure and to the personal factor. Fatigue, strength, skill, prejudice—all might affect the results. It seems easy to avoid this by testing the wheels on some automatic machine; but, as has already been shown, the automatic machines in use are intended for special work, and such machines do not demonstrate the comparative value of wheels for general work. You will wonder, then, why some enlightened wheelmaker, anxious to establish his business on a scientific basis, has not invented a test machine. This problem, which seems so easy, has been attempted, and has proved, for years, an insoluble problem. Its solution will enable the wheelmaker to demonstrate the comparative value of all the various makes of wheels—of his own varied grades and

classes, and of the various abrasive materials in use. It will enable him to estimate the resisting power of the various metals and other substances to be ground. It will enable him to calculate with certainty as to what speeds, pressures and sizes are most economical. And from these facts will arise the ability to furnish special wheels for each particular substance. From these facts will result regular practice and it will be possible to predict and to secure definite results.

Now, not infrequently, the vague order comes, "Send me an emery wheel!" Now, the best wheelmaker knows that there is little chance of his wheels being used under proper conditions—that there is still less chance of any one special wheel being allotted to one special work, and run under the conditions best fitted to give the most economical results. Now, his strife is to limit and simplify his variety—to give only a few degrees of difference in coarseness and fineness, in hardness and softness. His object is to supply wheels which can be shipped in quantity to all parts of the earth, and which are so fitted for all general uses that the shopkeeper who carries a small stock can supply to the user who only wants one, or one dozen wheels, such wheels as will be safe to use under conditions both proper and improper, and which, under such conditions, will give satisfactory results for the most varied uses on the most varied substances. Such wheels, as the maker himself will tell you, are only compromise wheels. They may give satisfactory results, but they are not likely to give the best results.

When a mechanical test has been perfected—when a machine has been built in which the pressure applied to the wheel is measurable, and when the whole operation of the machine so simulates the general practice by hand as to make it a trustworthy guide—then special wheels can be made, each of which is adapted to some special metal.

When the user can apply to the maker with confidence for wheels best suited to any metal he may name; and when the wheelmaker can write back, "I send you a wheel which, under such a pressure, will grind so many pounds of

such a metal in an hour," then metal workers will be justified in the adaptation of the grinding process on the widest possible scale. In the meantime, they want to establish in their own minds what seem to be the established things in a complicated and sometimes obscure business, and to be on their guard against the delusions connected with it.

The first thing they want is a *safe* wheel; for fear of accident always was and still is a deterrent to the introduction of this process. Accidents more or less serious, and sometimes fatal, still occur. Let them set it down as one of the established things that while extra high or low speeds may have some special value, the best speed is not positively known, but that common consent fixes it at about 5,500 feet per minute. Inasmuch, however, as governor belts slip off, and engines run away, and mistakes sometimes occur, let them get a wheel which would be safe even in case of accident or improper use. A few words as to the safety of solid wheels are in order here. The industry as a whole has made progress, and accidents are much fewer than formerly. This is due to the facts that nearly all makes of wheels are better than they were and that they are run under better conditions. So evident is it that most of the accidents are due to misuse that few suits have ever been brought and we have not heard of a single verdict against a wheelmaker. In the earlier days of this industry an English emery wheel burst at an Agricultural show in Liverpool, where it was on exhibition, and killed a man. The coroner's jury not only exonerated the wheelmaker but brought in a verdict declaring that such wheels were much safer than grindstones. Still earlier suit was brought for $10,000 damages against a western user of an American wheel. This suit exonerated the wheelmaker from the start, for the claim was that the death was due to criminal negligence inasmuch as the wheel was run at a speed greatly exceeding that advised by the maker. The defendant brought evidence to show that that make of wheel was safe even if run at specified speeds vastly greater than that advised by the maker. On this defence he won his case. Of the accidents that do happen some occur from the same

ludicrous ignorance which causes mishaps under the most unlikely circumstances. Our own reputation was once ruined for quite a time in a large neighborhood. A countryman drove into town—bought a thin saw-gumming wheel at the country store—wrapped it in a piece of newspaper—threw it into the tail end of his farm wagon and drove twenty miles home through a soaking rain. Finding the wheel wet he baked it all night in the oven of his kitchen stove and was killed by it the next day.

Other men have been killed by their distrust of the wheel and their elaborate but mistaken precautions to render it safe. It has been well claimed that any wheel which was not safe to run a mile a minute without mechanical reenforcements of any kind was not safe at all. Distrust all wheels which have to be made safe by low speeds, by extra large flanges, by wire webs, by safety coverings. The object of a flange is not to keep a wheel from bursting, but to keep it from turning upon instead of with its spindle. He who trusts to flanges to keep in the fragments of a wheel too poor to hold together of itself trusts most mistakenly. There is no exception to this rule, though a seeming exception exists in the quite proper use of extra large flanges for thin wheels of large diameter. This, however, is not, as it might seem, to hold the fragments in, but to prevent the breaking of a thin wheel by side pressure.

That wheel is safest which does not have an iron or stone hub or centre, but which is of one homogeneous composition and has a mandril hole adapted in size to the spindle on which it runs. The unequal expansion of heterogeneous materials is a danger any mechanic can understand.

Fine spun theories as to the various processes of wheel making may be left unconsidered by the buyer, but he may consider one point as established. Every wheel which tends to glaze badly with metal is dangerous as compared with one which does not glaze. Every free wearing wheel is comparatively safe.

He, then, who wants safe wheels should avoid all that glaze quickly. He should avoid doubtful expedients to cheapen and make safe. He should use large flanges with

very thin wheels. He should have mandril holes of moderate size and very slightly larger than the spindle. He should mount the wheels substantially. And still, to be absolutely safe, he may add coverings and guards provided these are not of cast iron, but are of wrought iron, boiler plate or tough steel.

Another established point is that, as a general rule, increased wear of wheel indicates increased product in the amount of metal ground. We say increased product, not proportionately increased product. It is a nice point (yet to be decided by the invention and long use of a competent test machine), just how far wheel consumption and metal removal are proportionate. The careful observations thus far made seem to indicate that there is a reasonable average maximum removal of metal compatible with economical consumption of wheel material. That if, by increased speed or pressure, the wheel is made to wear out faster than this, more metal can be removed, but that the gain in metal removal is far more than balanced by the increased loss of wheel material. To illustrate this, we give the results of one carefully verified experiment.

A wheel of ten-inch diameter and one inch thickness, was run at the ordinary high speed of 5,628 feet, or 2,150 revolutions, per minute. At this speed, it ground off $1\frac{35}{100}$* ounces of cast iron in one minute, and the loss of wheel material was $\frac{9}{100}$ of an ounce for every ounce of metal removed. On increasing the speed to 8,377 feet per minute, or 3,200 revolutions, the same wheel ground off $3\frac{36}{100}$* ounces in one minute, but the loss of wheel material increased to $\frac{16}{100}$ of an ounce for every ounce of metal ground.

Speed. *Feet.*	*Metal Removal per Minute.* *Oz.*	*Wheel Loss per 1 Ounce of Metal Removal.* *Oz.*
5,628	$1\frac{35}{100}$	$\frac{9}{100}$
8,377	$3\frac{36}{100}$	$\frac{16}{100}$

Speed. *Feet.*	*Wheel Loss.* *Oz.*	*Metal Removal.* *Oz.*
5,628	1	11
8,377	1	6

* One-minute averages of two sixteen-minute series.

In other words, at the high speed one ounce of wheel material would only grind off six ounces of metal, while at the lower speed it would grind eleven ounces. To increase the metal removal about two and one-half times, the wheel loss had to be increased about four and one-half times, and the horse-power to drive wheel increased about fifty per cent.

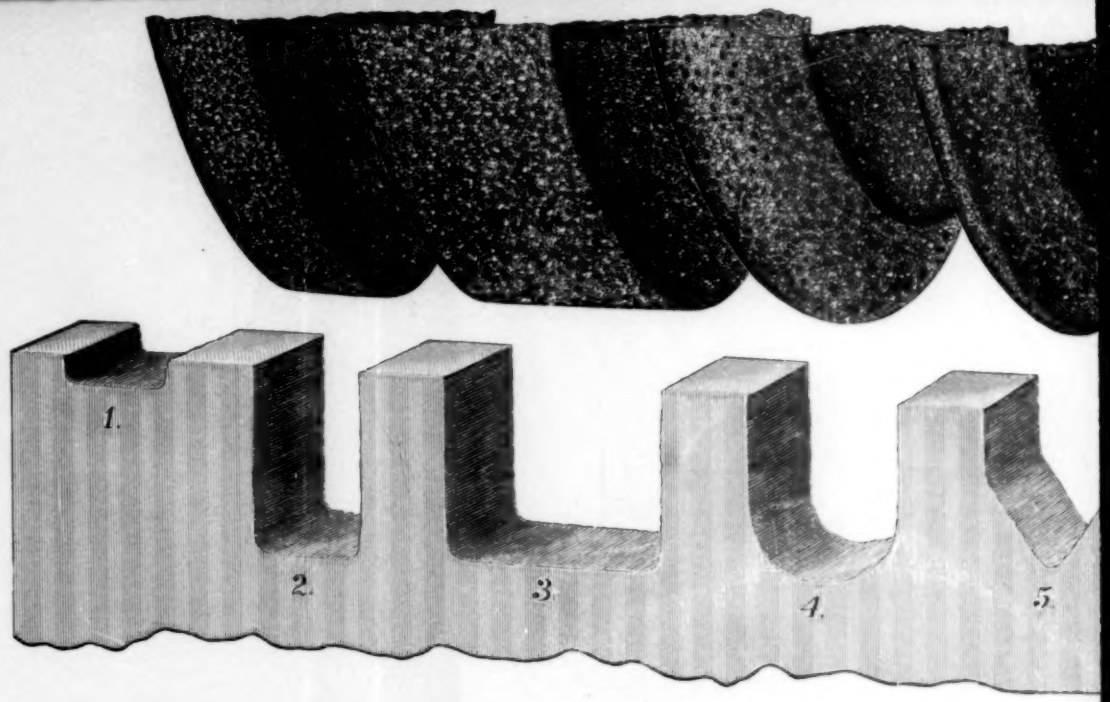
To balance this increase in the loss of wheel material, we have only the decrease in time and wages. Completing this problem by estimating the result in dollars and cents, we find that it cost almost one-third more to grind off one ounce of cast iron at the speed of 8,377 feet than it did to grind off the same amount at 5,628 feet.

While too few observations have been made to allow of certainty, yet it would seem as if rapid wear of the wheel was a sure indication of rapid grinding or metal removal.

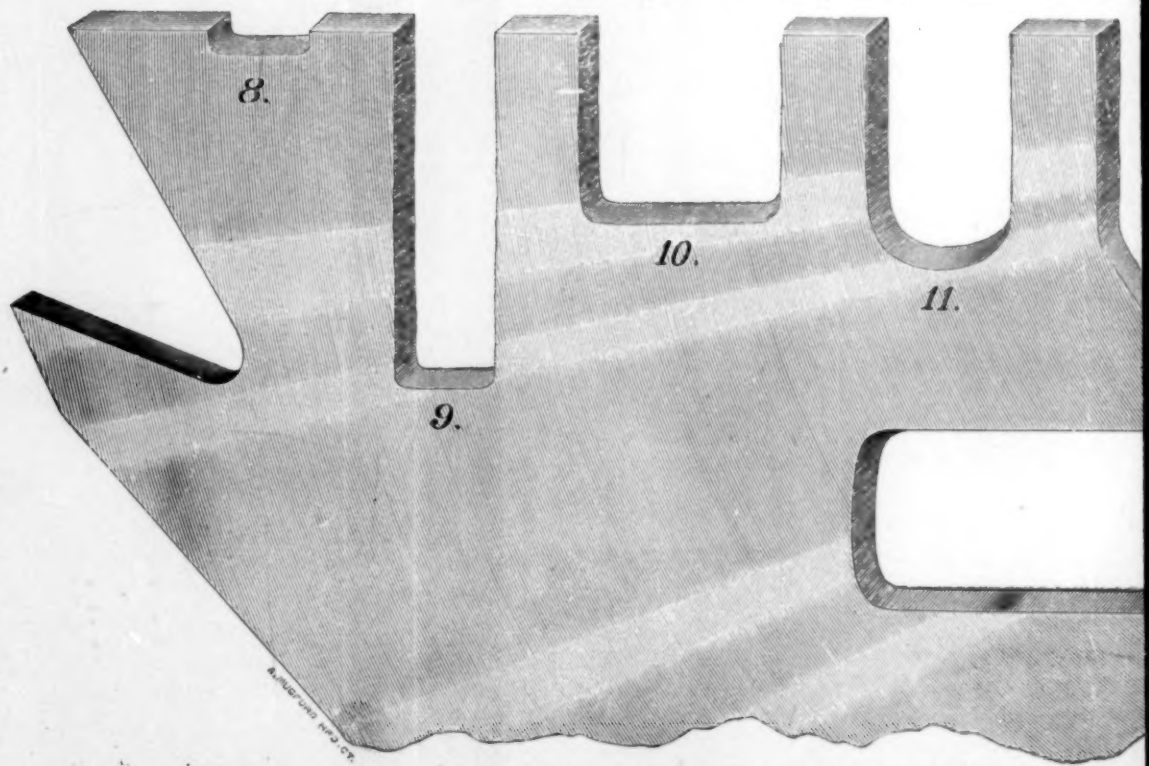
The user must be on his guard, however, against one delusion, and that is that the softest or most rapidly wearing wheel is the most economical. If he finds a wheel which wears out with great rapidity, let him beware of big wheel bills. If he has a wheel whose wear is reasonable, but can be made very great by increased pressure or speed, let him beware of such increase. It is proper to say, however, that of all the American makes only a very few are essentially soft. By far the greater number are essentially hard. The great and all-prevalent delusion is that durability is the test of perfection in a solid wheel; and the almost universal practice is to use wheels which are too durable. The man who sees a continuous stream of fire flow from his wheel and finds the metal wearing off reasonably; that is, as near as he can guess; and who finds his wheel to wear out slowly, this man always assumes that he has an economical wheel. Now the whole accumulated bulk of many years' experience convinces us that this is not true. That experience is not tabulated, and therefore we cannot demonstrate our position. We admit that there are some exceptions to the rule. And yet, whenever we are shown a wheel of which the user boastingly claims that it has lasted for years, we feel that such wheel might better have been

Figs. 2 to 7, both included, show in exact size and shape the cuts made by a set of tanite emery wheels in a cast-iron plate one-half inch thick. Each cut was ground out in sixty seconds. *Fig.* 1 shows the cut made in same plate in sixty seconds by an expert filer, using an entirely new file with cutting surface of same width as that of wheel which cut slot *No.* 2, viz: one-half inch.

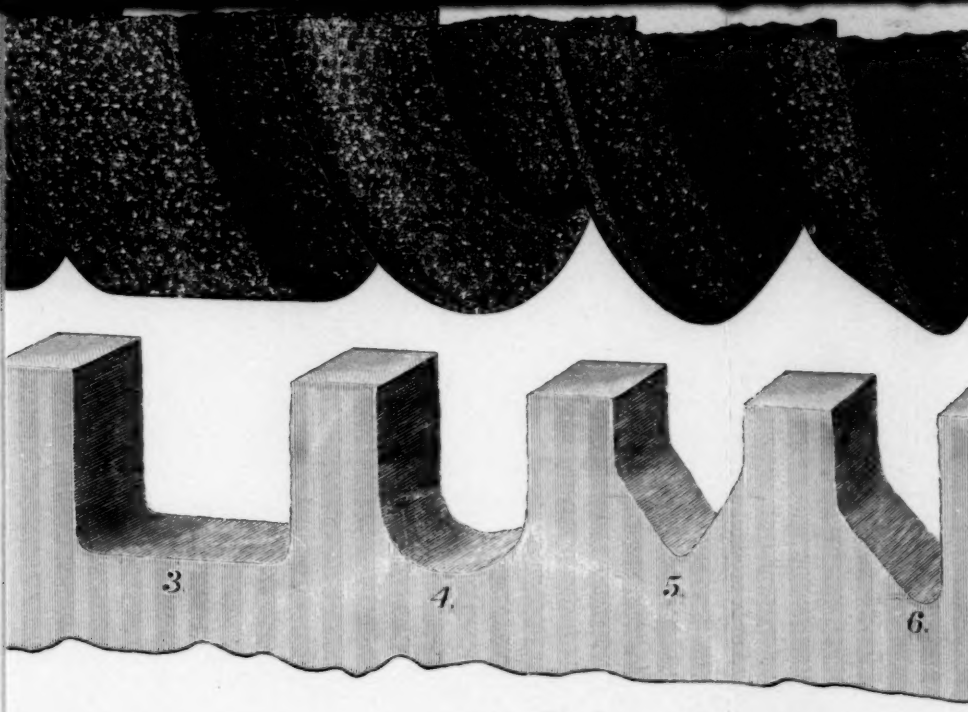
Figs. 9 to 14, both included, show in exact size and shape the cuts made by same set of wheels in a circular saw of No. 9 wire gauge, American standard, viz: one-eighth inch scant, or three millimetres thick. Each slot was ground out in sixty seconds. *No.* 8 shows the slot made by a new file in sixty seconds. In the cast-iron plate slots 1 and 2 correctly indicate the comparative work of tools of same width. In the saw steel, 8 and 9 should be compared. Neither file nor grinder can maintain the one-minute rate of work for any length of time, and it is not possible yet to state in what proportion the rates would decrease, or what would be a fair day's average for each. It is proved that the filer's rate decreases much more rapidly than the grinder's. It was hard work on the man to file slot *No.* 8 in sixty seconds, and the teeth of a new file which was used in cutting this one shallow slot were worn dull. As demonstrated by *Nos.* 8 and



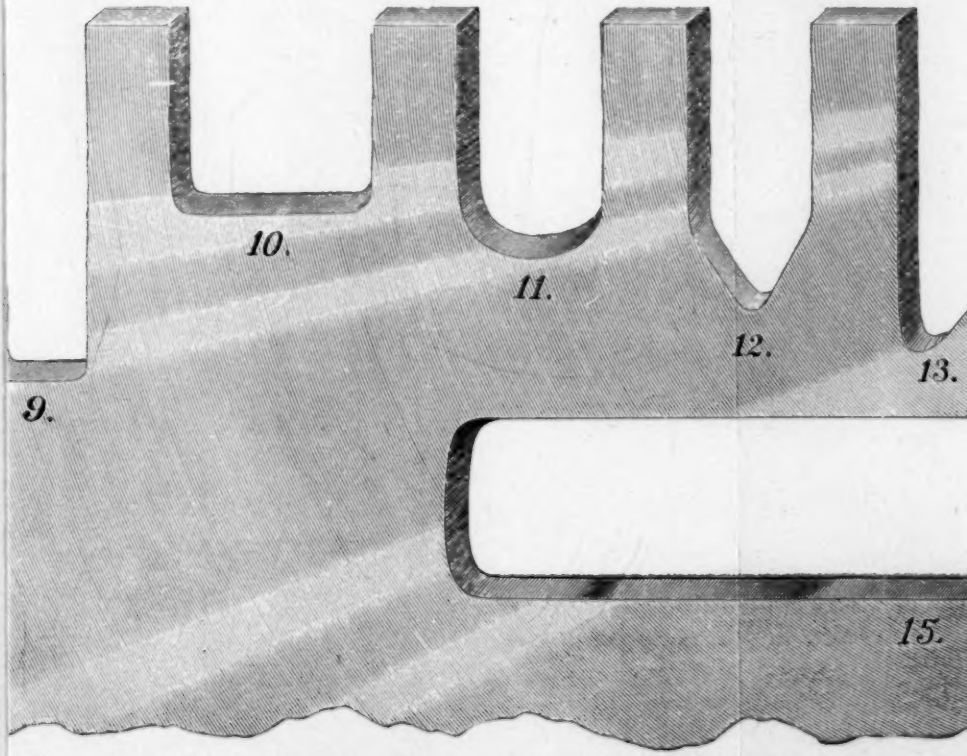
Comparative Cuts by a File and by Emery Wheels in a Cast Iro



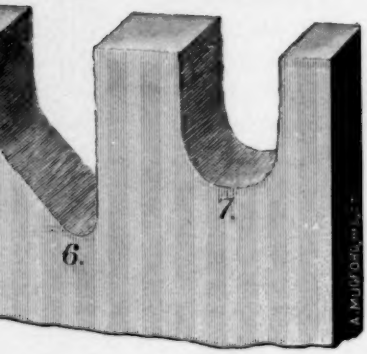
Comparative Cuts by a File and by Emery Wheels in a Circular

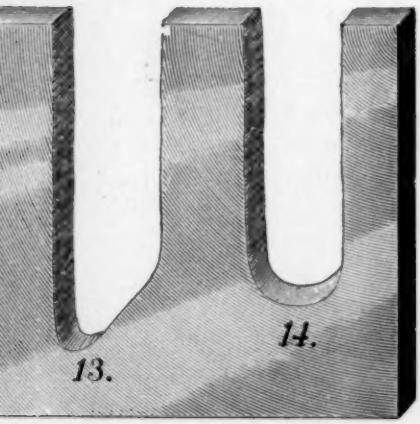


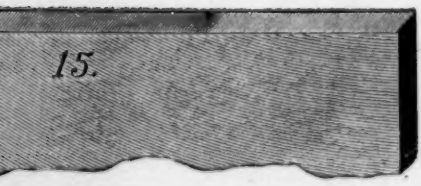
Comparative Cuts by a File and by Emery Wheels in a Cast Iron Plate.



Comparative Cuts by a File and by Emery Wheels in a Circular Saw.



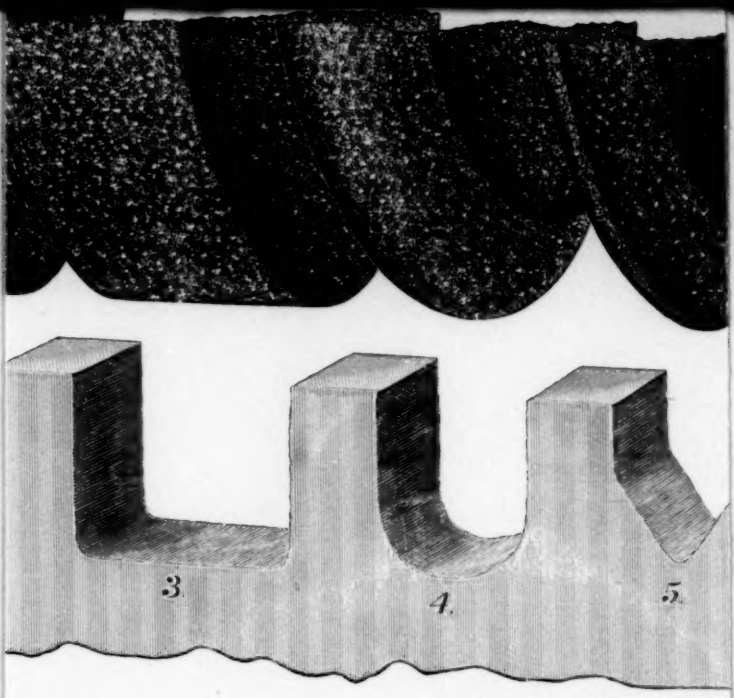




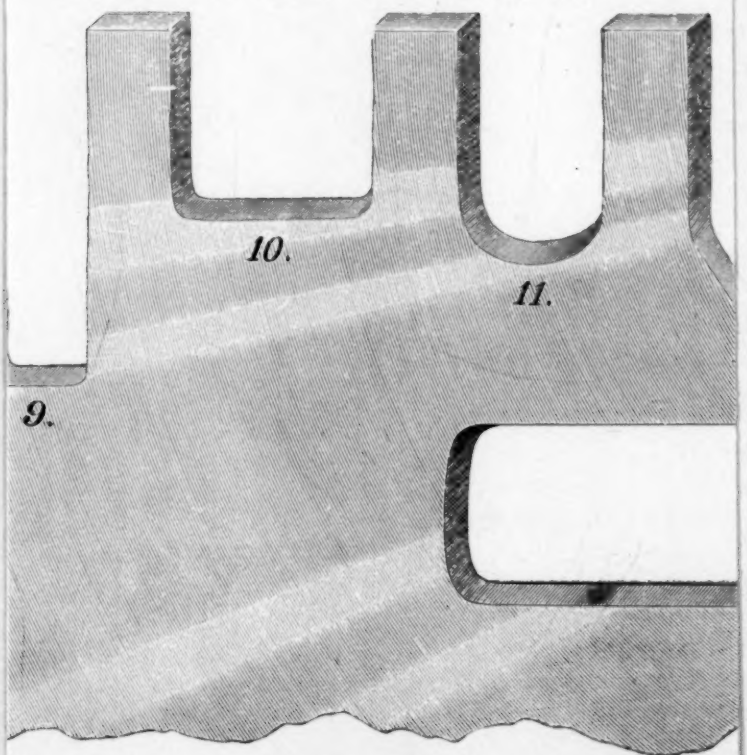
9, the emery wheel did about sixteen and one-half times as much as the file.

The emery wheels used in cutting the slots shown in these illustrations were tanite wheels, class 2. This class is of emery neither very fine nor very coarse, and it is neither the softest nor the hardest of various qualities. It is selected as a compromise or average wheel. These wheels were mounted on a grinding machine weighing only forty-four and one-half pounds, the machine standing on an ordinary wooden vise bench, and driven by a two-inch belt, running so loosely that belt slipped and speed of wheel was variable.

Now observe slot *No. 15*. To grind this out, an old tanite wheel, soft and free cutting, but of unknown class, was picked up in the shop. This wheel was mounted on a machine weighing 662 pounds, standing upon, and bolted to and through, a mass of stone and concrete over three feet deep, and was driven by a four-inch belt, a tightener pulley being so used as to prevent all slip and to maintain the maximum speed. This slot was cut in *only thirty seconds*. If it were the same width as slot *No. 8*, it would show that the emery wheel had done sixty-three times as much work as the file; but as it is fifteen-sixteenths inch wide, the work done is actually 126 times as much.



Comparative Cuts by a File and by Emery Wheels in a Cast Iro



Comparative Cuts by a File and by Emery Wheels in a Circula

thrown out of the window. As we have already said, at one time during the rapid growth of the wheel industry, the dry wheel came into almost universal use in America. With the early growth of the industry in Great Britain, one of the first machines gotten up was a very excellent form of wet grinder, for tools, which is still freely used. Going to that conservative city, Glasgow, to introduce our American innovation, a soft, free-cutting wheel, a foreman told us that he was already provided. He pointed out, complacently a wet tool grinder, and starting the wheel at full speed, deliberately pressed his thumb against it. Discomposed at our sudden laughter, he asked what was the matter, and was told that he would have no thumb left if he pressed it against a typical American wheel. We doubtingly tried the thumb experiment on his wheel and found it like a lubricated disk of polished marble.

Let him, then, who boasts of a durable wheel, beware of its durability.

While our whole experience on this point is not tabulated, a little of it is, and we ask you to note the results of one series of exact experiments. We give you the wear of wheel and the removal of metal in the case of seven wheels of the same make, but of varied quality. The wheels were tried under equal conditions, each trial being one-half hour long and the metal being cast iron.

Metal Removal. Oz.	*Wheel Loss.* Oz.
37½	* Nothing.
64½	3
77	2½
100½	13
122	6
187	26
196	39

While the progression in this table is not perfectly regular yet it indicates a general law, and the wheel which did scarcely any grinding was the most durable of all, and that which ground the fastest wore out with great rapidity.

* As all very hard wheels glaze, there probably was a slight loss of wheel material which was balanced by the adhering metal.

As bearing still further on this point we ask attention to some results of tests made with ten different makes of wheels. These wheels were run under identical conditions, the amount of metal removed being weighed at the end of each minute. Out of ten makes only two maintained their cutting capacity unimpaired, removing at the last cut as much as at the first. All the others rapidly deteriorated. At the end of the sixteenth minute, four of them had been reduced to a metal removal of only one-sixteenth of an ounce per minute, and one to two-sixteenths. Even the wheel whose initial cut was the greatest—three and one-sixteenth ounces in one minute fell off to one and four-sixteenths ounces in the sixteenth minute. That whose initial cut was the least—five-sixteenths ounce in one minute—fell off to one-sixteenth at the fourth minute and never increased. Of the ten makes only three cut well. These three wheels ground off $127\frac{7}{16}$ ounces with a loss of eighteen and thirteen-sixteenths ounces in wheel material, while the other seven ground off fifty-one and ten-sixteenths ounces with a wheel loss of one and nine-sixteenths ounces.

The noteworthy thing about all this is the possibility of delusion to the ordinary worker. While the wheel is running the eye would detect little or nothing to suggest the enormous discrepancy of result. Unless the pieces being ground were uniform the worker might easily be misled as to the metal removal. If he made the most careful observation as to capacity of wheel at the beginning of his work—as he naturally would whenever he mounted a new wheel—the initial capacity would be no guide to the average. One of the wheels whose initial cut was excellent—two and nine-sixteenths ounces in the first minute—fell to three-sixteenths on the twelfth minute. And this wheel when examined after the sixteenth cut, in which it only removed one-sixteenth of an ounce, was comparatively unglazed, and of such open texture as to make it in appearance a typically good wheel. The three wheels which did good work were much more compact, and if selection were made by appearance only, these would have been discarded.

A great and general delusion is as to the power required

to drive emery wheels. Even many of those who have somewhat reluctantly been driven to the successful use of the solid wheel believe that its enormous capacity is secured at the cost of a power consumption which they are afraid to calculate and face. I have never seen any published statement on this subject, but am prepared to state positively that the power is much less than imagined. To drive a 10 x 1 solid wheel, weighing about ten pounds, at a speed of a mile a minute, with a metal pressure against it of forty-two pounds, only one and one-half to two horse-power is required.

Mr. Chairman, I am an advocate of dry grinding and this is a dry subject. But I am not an advocate of dry lectures, and I fear this is too dry. It might have been made still drier by the use of technical terminology and tabulated figures. I have deemed it wiser (as the subject has been seldom publicly treated of), to use simple language and clear illustrations. My object has been to state forcibly the convictions based on twenty-two years' study and practice of this industry, while frankly admitting how few of those convictions can be verified by statistics or vouched for by other testimony than my own. To indicate to students and experts how wide, interesting and unexplored a field this industry offers. To invite them to observe and report, so that crude theory may be transformed into science by the accumulation of exact data. And, lastly, to call in workmen, foremen, superintendents and buyers as helpers in the work of elaborating from a small industry a great economy.

ON SCHOOLS: WITH PARTICULAR REFERENCE TO TRADES SCHOOLS.

BY JOSEPH M. WILSON, A.M., C.E.
President of the FRANKLIN INSTITUTE.

[*Continued from vol. cxxix, p. 101.*]

L'ÉCOLE MUNICIPALE DE PHYSIQUE ET DE CHIMIE INDUSTRIELLE, RUE LHOMOND NO. 42 (VISITED).

This is an old building, the arrangements and fittings for giving instruction in physics and chemistry being rather primitive. There is some excellent apparatus, and apparently plenty of room in which to arrange apparatus for special investigations. Investigations of great importance have been, and I have no doubt are being made here, but there is nothing specially worthy of imitation in designing a new structure. Many far better examples for schools of applied science are to be found in Germany and England. I witnessed some interesting experiments that were being made on sound, in one of the departments, at the time of my visit.

The school had a fine exhibit of chemical and physical apparatus at the Paris Exposition.

ÉCOLE MUNICIPALE ESTIENNE, ÉCOLE PROFESSIONELLE DES INDUSTRIES DU LIVRE, 14 RUE VAUQUELIN (VISITED).

This school, which I understand has been but lately organized, had not commenced its sessions for this year, at the time I visited it, and I did not, therefore, have an opportunity of seeing the pupils at work, but I went through the buildings and saw the different departments as arranged for work, together with specimens of the kinds of work done and the Director who accompanied me was exceedingly obliging and profuse in his explanations.

An examination for the admission of seventy pupils was to be opened on October 7th, a few days after my visit.

This is a day school for boys, its object being the production of workmen skilled and learned in the different industries connected with book-making The instruction is gratuitous and breakfast scholarships are given for proficiency. The school hours are from 8 A.M. until 6 P.M., and the full course requires four years. Boys are taken at from thirteen to eighteen years of age, and during the first year they pass through all the workshops of the school, the system being similar to that at the École Diderot, during which time each pupil is supposed to discover the special department for which he is best fitted. At the beginning of the second year the pupils are distributed to special trades, and during the next three years they pass through their apprenticeships.

The accompanying tables show the general programme of the course of exercises and studies for the first year.

The students receive certificates of apprenticeship at the end of the fourth year, and medals and premiums are also accorded to those who have fully passed the final examination tests.

The entering examination is in writing and comprises, (1) a dictation; (2) two problems in arithmetic, simple applications of four operations, in entire numbers, in decimal numbers, in fractions and according to the metric system; (3) a simple embossed ornamental design.

A candidate for admission to competition must first furnish proof that he is a native of France and a resident of Paris, and that he is over twelve years of age and not more than fifteen at the date of the commencement of the term year (November 11th). He must be provided with a certificate of primary studies.

Applicants for entrance examination must furnish certificates of birth, of primary studies and of vaccination.

Children from the suburban districts of Paris can be admitted to the school on a guarantee from the suburban authorities of 200 francs per annum for each child.

In passing through the buildings, attention was called

to the excellent facilities provided for teaching engraving on wood, copper, zinc, stone or steel; to the foundry department, where the practical operation of type casting is carried out; to the photograph and phototype department; to

PROFESSIONAL INSTRUCTION.

WORKSHOP.	FIRST YEAR.
Type-founding.	Elementary instruction in hand-moulding. Machines for type-casting, rubbing, cutting justification and sizing of letters, the placing in pages, the pointing, the matrices and the electrotyping.
Typography.	The apprentice receives some preliminary instruction on the subject of type: the material, the composition, the impression (especially with hand-presses) stereotyping.
Sewing.	Elementary ideas, drying, drying ropes and assembling, study of sizes, folding, marking, stitching, putting in pages, trimming, edge-cutting with press and machine, packing.
Binding.	Rolling, preparatory labor on the body of the work, unstitching, refolding, assembling, placing in plates, mounting of guards, stitching, putting in packets, wetting of covers, covering and putting in press; covers for half-bound classics.
Gilding.	First elements.
Wood-engraving.	Drawing of parallel lines to give a gray tint, shaded tints, then designs in line, and designs with some shading; the apprentice will engrave designs that he has previously drawn on wood. Taking off proofs.
Stone-engraving.	Drawing of straight lines, curves, impressions on paper and on stone. Letters in large and small characters. Drawing of lines of different degrees of thickness. Execution of small cards, of fine lines with corresponding letters. Transferring cards, designs, reductions and enlargements, lithographic impressions.
Engraving on copper.	First elements, elementary notions in engraving on copper and copper-plate impressions.
Designers and engravers on stone.	Counter-tracing of designs, transferring on stone, use of the crayon and pen on stone, drawing of straight and curved lines both in English and round styles. Taking off proofs.
Photography.	The student will be initiated into the photographic operations necessary to obtain plates intended for engraving, also in the operations of photo-engraving and phototyping, and of the taking of proofs of such work.

the type-setting room, the electrotyping-room, the carpentry, machine and blacksmith shops, of capacity sufficient to teach pupils to make repairs to machinery themselves, etc. There is a department for artistic drawing and modelling, and a

museum for a collection of objects indicative of the progress of the arts of printing, engraving, etc. Additions are constantly being made to it and the collection is growing in value as time passes. The bookbindery is provided with the various machines necessary in the trade, ruling and paper-cutting machines, stamping presses, gilding utensils, etc.

THEORETICAL INSTRUCTION.

COURSE.	FIRST YEAR.
French language.	Orthography, choice pieces.
History.	Elements of general history. History of the book industries.
Geography.	Elements of cosmography. General geography of the globe.
Elements of mathematics.	Arithmetic. Typographic numbers. Metric system. Topographic signs. Elements of plane geometry. Measurement of surfaces. Typographical problems. Surveying.
Natural history.	Elements of natural history.
Chemistry.	Practical information in industrial chemistry. Manipulations.
Physics and mechanics.	Practical information.
Object drawing.	Ornaments in relief.
Modelling.	First elements.
Geometrical drawing	Elements. Letters or figure drawing, lines, surfaces.
Reading and writing.	Divers manuscripts. Reading and writing of foreign languages.
Gymnastics and military exercises.	Athletic exercises. Marching. Walking. Drilling. Elementary individual exercise. Military exercise.

The buildings are only provisional, it being the intention to erect hereafter a more complete structure exactly adapted to the wants of the school. The school probably has no precedent of its kind, and it is an excellent idea to establish it first in temporary quarters until it can be discovered by actual practice what the requirements are in the way of permanent buildings.

INTERNAT MUNICIPAL DES PUPILLES DE LA VILLE DE PARIS, 72 AVENUE PHILIPPE AUGUST (VISITED).

This school is a pension for boys of seven to fourteen years of age, selected from among those who have been left as foundlings to be brought up by the city, never having had any acknowledged father or mother.

The building is quite a new construction and will accommodate 130 boys. It appears to be very suitable for its purpose; it is kept in good, clean condition, the dormitories are of good size, well lighted and ventilated, and the beds comfortable. The washing-room and sanitary arrangements are reasonably good, but in such matters the practice in the United States is believed to be ahead of anything on the Continent of Europe.

The usual primary course of education is taught, including drawing and modelling, and practice is given in the workshops in iron work, including forge and machine work, and in carpenter work, the kind of work being such as is adapted to the age of the child. After trial of a certain length of time, each boy is allowed to choose which particular department or trade he will follow as a business. A large play-ground is attached to the building with facilities for gymnastic exercises.

The kitchen department gave evidence of good wholesome food and plenty of it. The boys appear robust and healthy. This school is a little out of our present line of inquiry, except in that it provides for manual training, but it is a good specimen of its class, of which there are quite a number in France.

The Exposition gave some very interesting exhibits from the Écoles Municipales Elementaires; models, specimens of carpenter work, etc.; also from the Ville de Paris Chaptal; drawings from casts and from life, ornamental, architectural and machine drawing, etc.

A society exists in Paris for the professional education of girls, not supported by the government, but largely by private charity and by contributions, a small charge being made for each pupil.

There are three schools operated under the auspices of

this society: "Écoles professionelles pour les jeunes filles" (Écoles Elisa Lemonnier), their location being at No. 24 rue Duperré, 70 rue d'Assas and 41 rue des Boulets. (Visited.)

These schools are especially designed to prepare young girls for employments of commerce and industry. Only day scholars are received. Candidates must not be under the age of twelve years, and they must pass an examination before admission.

The courses of study, which require three years for completion, are designated as general and special. The general course comprises a solid instruction (see programme), in the French language, arithmetic, geometry, history, geography, science as applicable to the usages of life, writing and needlework.

The special courses, eight in number, are as follows: Commerce, industrial design, dress-making and making of underclothing (*atelier de confection et de lingerie*), engraving on wood, painting on porcelain and faience, painting on glass and embroidery for furniture covering.

The following gives the programme of studies in detail:

PROFESSIONAL SCHOOL FOR YOUNG GIRLS.

Ecoles Elisa Lemonnier.)

PROGRAMME OF STUDIES.

GENERAL COURSES.	PREPARATORY COURSE.	FIRST YEAR.	SECOND YEAR.	THIRD YEAR.
French Language.	Reading with explanation, narration, French grammar, grammatical analysis.	French grammar, orthography, grammatical analysis, elements of logical analysis, style and narrations.	Continuation of grammatical studies, logical analysis, style.	Style and composition, elements of general literature.
Arithmetic.	Mental calculations, operations with integers and decimals, metric system.	Metric system, fractions.	Interest, discount, rents, proportions, square root.	Completion of the course.
Geometry.	Elements of linear drawing.	Elements of linear drawing.	Course of geometry, numerical applications.	Completion of course, problems.
History.	Elementary history of France.	Elementary course of French history until 1789, ancient history.	History of France until 1648, mediæval history (1453), Grecian history.	History of France until 1848, history of modern times, Roman history.
Geography.	Elementary general geography, local geography.	Geography of France.	Geography of France and Europe.	Geography of France, Europe and the other parts of the world, France commercial and industrial.
Sciences applicable to the uses of life.	Lessons of things.	General preparation to the courses of physics, chemistry and natural history.	Physics and natural history.	Chemistry, applications of physics and chemistry, zoölogy, anatomy, botany, physiology and hygiene.
Writing.	First principles.	English rapid, round.	Special styles, round, inclined.	
Course in sewing.				

SPECIAL COURSES.

PROGRAMME.	PREPARATORY.	FIRST YEAR.	SECOND YEAR.	THIRD YEAR.
Commerce. { Accounting, English and German languages.		Elements of book-keeping, auxiliary books, principal books, commercial writing, balances, documents showing the operations, invoices, statements, receipts, payments.	Revision of the principles of book-keeping, complicated commercial operations, balancing, inventory, balance, study of commercial papers (documents), list of discounts, calculation of commercial interest, accounts current.	General accounting, opening and closing of books, calculations on foreign money, elements of civil and commercial law.
Industrial design.	Geometrical drawing, elementary exercises of application.	Designing. { Objects, geom. solids. / Ornaments / Flowers, / Figures, } from object and from nature.	Descriptive geometry, elements of perspective.	Perspective and applications to design, composition.
Confection.		Sewing.	Assembling and ornaments. Reduction of patterns	Designing and patterns, cutting.
Wood-carving (Rue Duperré).	This course takes 4 years.			
Painting on porcelain and faience (Rue Duperré and Rue d'Assas).	This course takes 4 years.			
Painting on glass (Rue des Boulets)				
Embroidery for pieces of furniture (Rue des Boulets).				

Examinations for the general course are made on the first elements of French grammar and arithmetic; those for special courses are regulated by the nature of each course. At the end of each year, Commissioners of Examination interrogate the students and award certificates of capacity.

The school hours are from 8·30 A.M. until 5·30 P.M., the general course being taught from 8·30 to 11·30 A.M., and the special courses from 12·30 to 5·30 P.M. Two intervals of recreation are given, alternating with the studies, amounting to one and a half hours' rest.

At the opening of the school all absences are noted, and properly attested excuses are received. Parents are requested to notify the Director by a prepaid post-letter whenever a pupil is obliged to be absent, and if no such letter is received, notice is sent the same day to the parent by a letter not prepaid. The parents are also informed in the same way if pupils are late one-half hour or more without proper excuse.

The charge for pupils is 132 francs per annum, one-tenth being due and payable on the first of each month during the ten school months. The amount for each entire month is paid, no matter at what time during that month the pupil enters or leaves the school. No allowances are made for absences. Applications can be filed at any time.

I visited one of these schools, that at 41 Rue des Boulets, Mad. Fakler, Director. The building is a modern one, erected especially for the school, and the best for its purpose that I saw in Paris. It is a large house of three stories, with good height of floor and large windows, giving ample light; particular attention having been given to provide the light in the right direction.

The school will accommodate from 200 to 250 pupils. The sketch (not drawn to scale) shows the general arrangement of first floor.

The play-room has a brick or tile floor and the openings to the yard are large double doors, with the upper panels glazed, and when they are all open, almost the entire side of the room seems to be removed, affording a great influx of light and air. The yard is in gravel. The floors through-

out, except for play-room and basement, are of hard wood (parquetry plain design). The lecture-room has the usual sloping floor, the desks 3 feet 5 inches long by 26½ inches wide from one to the other, the walking passage between the rows being only sixteen inches. There is a good manipulating table for experimental illustrations, also closets for chemicals, etc., but as the course is probably not very extensive, the amount of apparatus required is not very great.

The second and third floors are divided up into class-rooms, the classes containing twenty-five, thirty or forty pupils each. The class-room for drawing is on the third floor, drawing being taught from models, from natural

1. Entrance.
2. Hall-way.
3. Reception-room.
4. Office.
5. Play and cloak-room.
6. Lecture hall.
7. Play-yard.

objects and from life. The drawing-room appeared to be small. The corridor partitions are glazed to within about three or four feet of the floor, and everything possible is done to give light.

The desks in the class-rooms are each 3 feet 9 inches long, and are placed nineteen inches apart, one to the other. The desks have a peculiar design of top, which throws forward a distance of seven inches after the pupil sits down. The tops of the desks are all painted black, probably in order not to show ink marks.

In the embroidery class very fine and beautiful work was being executed at the time of my visit. The dress-making

room is provided with cutting-out tables, about 2 feet by 6 feet in size, and stools are used for seats. Specimens of needlework were shown in cloth, linen and muslin. These examples were about six or eight inches square, each pupil making one of each kind, and those of like kind are bound together, making as it were sample books of the work. In cloth, there will be one piece showing a pocket, like a vest pocket, for instance, one edge and corner of the piece will be braided; another edge finished in a different way; a corner will be turned down like the collar to a vest; cloth collars, such as are worn on ladies' jackets, are made, button-holes are worked, etc., so that an opportunity is given for the pupils to learn all kinds of needlework.

In the examples of linen and muslin work, the same course is followed; there are all sorts of stitching, lettering, embroidery, etc., in white and colored threads. It was curious to note the examples of patching and darning in cloth, each pupil trying to make her specimen as neat as possible.

In dress-making, the pupils make measurements of the human figure, draw designs for the dresses, make the patterns, cut out and make up the dresses.

A kitchen in the basement affords facilities to the pupils for warming or cooking such parts of their breakfast as they may wish. Cooking is not taught however, and I was told that it was not taught in any of the schools of Paris. There is a breakfast-room in the basement, with marble tables, each table having one end built into the wall and the other supported by a single leg. The floor is of tile and stools are provided for seats.

ÉCOLE MUNICIPALE SOPHIE GERMAIN (VISITED).

This school was established by the city of Paris, in 1882, for the purpose of giving the young girls, who had terminated their primary studies, a general instruction to enable them to obtain employment in pursuits connected with commerce, industry, posts, telegraphs, railroads or banks; and to take secretaryships, clerkships or other positions connected with financiers, etc. The school is intended only for those

living in Paris, and the instruction is entirely gratuitous. The course is three years in length, with a fourth year added for a selected special course.

The programme is as follows:

First year.—Instruction, moral and civil; the French language, history and literature, general history, general geography, English language, German language.

Second year.—Arithmetic, geometry, book-keeping, political economy, physical sciences, natural sciences.

Third year.—Calligraphy, art design, linear design, cutting out and sewing, domestic economy, singing, gymnastics.

Special courses.—Commercial writing, commercial and industrial geography, commercial law, commercial correspondence in French, English and German; industrial and decorative design, composition, costumes, fashion and making of dresses and other clothing.

The exhibit of this school at the Paris Exposition was particularly fine, but in my visit at the building I saw nothing special to note. The school was not in session and the pupils not working, but the building did not appear very well adapted to its uses, probably being an old structure built originally for some other purpose. The course of study, however, is a good one, and the school is no doubt giving excellent results.

L'ÉCOLE PROFESSIONELLE DE LA RUE BOSSUET NO. 14 (VISITED.)

This is a day school for young girls from thirteen to nineteen years of age, and, I understand, is intended principally for educating teachers. The course of study requires four years, three of which are devoted to needlework, the English language, book-keeping and drawing. In the fourth year, glass painting, painting on porcelain and enamel painting, etc., are taught. The classes average forty to forty-five pupils each, for the first year, about thirty-five during the second year, and even up to fifty in the third year. Proficiency in the English language is considered very important for those engaged in industrial pursuits in France, particularly if they are engaged in the buying and

selling of goods, on account of their necessary contact with English-speaking people.

In this school great prominence appears to be given to teaching of dress-making. The girls are taken every week to the Bon Marché and other large establishments, to observe the latest styles in costumes and to examine and become familiar with the various fabrics in the market. After returning to the school they are obliged to sketch designs for costumes, to make drawings, to a scale, for the various parts of these costumes, to enlarge these drawings to full size patterns, and finally to cut out and make the costumes, working over the human figure or over models. The pupils are taught to make all articles of dress and underclothing, and I am told that at this school they even make dresses for customers; in fact, I was shown the reception-room where such customers could be received. Specimens of work from this school, including handsome dresses, were on exhibition at the Exposition. The pupils are also taught to make shirts and underclothing for men, and to work in cloth. Book-keeping is taught in a very thorough manner, each girl keeping a full set of books, and the specimens shown, picked at random from among the work of the scholars, were models of neatness.

Drawing is taught both from casts and from life, as well as designing of patterns, *motifs* for glass painting, fan-painting, etc. In glass and porcelain painting, the work is finished complete and fired as usual.

The school hours are from 8.30 to 11.30 A.M. for study in classes, an intermission until 1 P.M. for breakfast and recreation, and then work in the ateliers until 5.30 P.M. A breakfast-room is provided, furnished with tables and stools, the same room being used as a hat and cloak-room. Two hundred and fifty scholars can be accommodated.

The building is not remarkable, an old structure having been adapted for school purposes. In fact, I may say here that I found nothing in the way of buildings, at any of the schools I was able to visit in Paris, which would be of use as a precedent in designing new school buildings for the United States. The school of the rue Bossuet had an excellent exhibit at the Exposition.

France is doing very good work in the teaching of women, and will probably do more. One who has seen much of this work, very truly says, that the women of the middle classes in France are the salvation of that country. Patient, hard working, steady, attentive to duty, going out and laboring for the support of the family and the paying of the taxes, while at the same time keeping the house at home; it is to woman that France must look for her prosperity and it is woman that the Government should aim to improve so as to enable her to earn her living in the best way possible.

HAVRE APPRENTICESHIP SCHOOL.

This school is of the same type as that in the Boulevard de la Villette, Paris, and it is considered one of the most complete of its kind as to buildings and fittings. Its course of instruction requires three years; its theoretical instruction is more elementary than that of la Villette and the requirements of admission much less, even absolutely illiterate children having been allowed to enter if showing manual dexterity.

The school hours are from 6.30 A.M. to 6 P.M. in summer, and from 8 A.M. to 7 P.M. in winter, with two hours for dinner and recreation, between 12 noon and 2 P.M. Six hours are spent each day in the shops. Some of the classes have manual work in the morning and theoretical studies in the evening, while other classes have the reverse. This has the advantage of increasing the capacity of the school, but it would seem, that as a rule, theoretical instruction would be better in the morning when the pupils are in a more active condition of mind, and manual work in the afternoon. The studies are French, arithmetic, reading, dictation, composition, writing, history and geography, geometry and mechanics. One to one and a half hours is given each day to drawing. The pecuniary rewards at this school are much higher than at the Paris schools.

ÉCOLE LA MARTINIÈRE, ÉCOLE DES SCIENCES ET ARTS INDUSTRIELS DE LYON.

This school, which occupies an ancient Augustine convent in the city of Lyons, was founded in 1831, under royal

authority, in virtue of a legacy of 750,000 francs, left to his native city by Major General Martin, who died at Lucknow in 1800. The funds of the school have since been increased from time to time by further bequests from other donors, to a very considerable amount.

The school is governed by a commission, of which the Mayor of Lyons is *ex-officio* President, and seven other members appointed by the Municipal Council of Lyons with the approbation of the Minister of Commerce.

It is a "professional" school for boys and girls and is intended for the study of the sciences and arts as applied to industries and commerce. Its aim is not to prepare the student for the special work of any particular profession, but to educate him in such a manner that he may succeed in whatever profession he adopts, with the advantage of an intelligent start, a habit of scientific reasoning, a relatively liberal education, and especially that enthusiastic spirit for his work which is the dominant characteristic of graduates from la Martinière.

The course of studies requires three years, the instruction is entirely gratuitous and only for day scholars. The subjects taught are as follows:

First year.—Mathematics, design, grammar, physics, chemistry, history and geography, writing, manual work in the shops, sculpture, military exercise.

Second year.—Mathematics, design, chemistry, grammar, English, book-keeping, physics, weaving or work in shops, history and geography, writing, military exercises.

Third year.—Mathematics, mechanical design, architectural design, chemistry, grammar, English, book-keeping, physics, weaving or shop work, visits to manufactories, commercial geography and history, military exercise.

Those not living in Lyons can place their children in various pensions or families of the city. The school opens at the beginning of October. No admissions are allowed during the course of the school year. The course for the year terminates at the beginning of July and is followed by

the general examination to determine the rewards and the admissions to the second or third year, the distribution of prizes taking place before the first of August.

The conditions of admission state that candidates should not be over thirteen years of age, and the entering examination comprises:

In Mathematics.—Numerals, the four rules as applied to entire numbers to vulgar and decimal fractions, the metric system, problems.

In Grammar.—A dictation selected from a high-class standard writer, for the purpose of judging in reference to writing and orthography.

In History and Geography.—History of France to the end of the twelfth dynasty, and geography of France.

Candidates are obliged to apply in writing to the Secretary of the school, as indicated in a special notice given out each year at the beginning of September; they must show their certificates of birth, of vaccination or small-pox, and of the schools which they have previously attended.

Parents, tutors or sureties must sign an agreement that they will not allow the student to discontinue the course of the school, under any pretext, but that if he absents himself they will return him.

Students declared admissible to the course of the second or third years, must register their names again with the Secretary.

Students are not allowed to be absent unless from sickness, and in such case the parents must notify the Director.

Frequent interruptions, making it impossible for the student to continue the course of the school with success, will necessitate his removal.

A student who returns after an absence must be accompanied by his parents.

If a student is absent without the knowledge of the parents, they are notified immediately of his absence, and the cause is requested.

The Director is the only one who can give permission to the student to be absent.

The students must appear in a proper and decent dress.

The punishments employed at la Martinière are as follows, in order of the gravity of the case:

(1) A verbal reprimand by the professor.

(2) A bad mark, which punishes a slight fault.

(3) Detention after school hours to punish a grave fault, or in consequence of a certain number of bad marks.

(4) The admonition of the Director, with notice to the family, which applies to pupils having bad marks for their work or conduct and who have already merited too many detentions.

(5) Finally a dismissal, which is pronounced without hesitation when a student rebels to all other means of correction and is a bad example for his comrades.

The awards accorded in the course of the year are:

(1) A mention of work and progress accorded by the professor, as a gratification and praise to the pupil.

(2) The position and insignia of "brigadier," a rank of the first order in the general classing.

(3) And above all a "tableau d' honneur" put in a public position, giving the names of the best students, at the time, for their work and conduct.

At the end of each month, in those courses which have a great number of weekly lessons the students undergo a competitive examination for the purpose of determining their grade in their corresponding classes. At the end of each quarter there is a written or oral competition in all the courses without exception. These competitions serve to classify the students generally, and the classifications are affixed in a prominent place in the school. The first twelve on the list of students in the general classification are rewarded with the rank, insignia and duties of "brigadier," and their names are inserted on the "tableau d' honneur."

At the end of the year the students are subjected, in all the classes, to a competition, more important than those of the two other school quarters, which competition determines the rewards and serves as the basis of a classification for the lists of students who can pass from the first to the second year or from the second to the third.

Examinations are made at the end of the third year, in all the courses, by committees composed of professors, merchants, manufacturers, engineers, artists, etc., selected from those belonging to the school and also from strangers, and the awards are conferred on the students with considerable ceremony, thereby enhancing their value. They consist of honorable mentions, medals, books and useful objects, such as boxes of mathematical instruments, etc., and a certain number of books for savings banks are also distributed among the most meritorious students.

First and second-class diplomas are awarded to students who at the end of the third year have obtained a sufficient number of commendatory marks.

The Director forwards to the parents, at the end of each quarter, a bulletin of the conduct and work of the students and he also writes further in detail whenever the conduct of the student requires it.

The school will extend its care over all students in good standing after they terminate their studies, if they so desire, in endeavoring to obtain good positions for them, and for this purpose a register is opened in the office of the General Superintendent to receive applications from employers or from those desiring employment.

The administrative commission of the school appoints and dismisses the teachers, selecting them as far as possible from among the old students of the schools, after they have completed their instruction as masters and have obtained diplomas either as secondary teachers or, for employment in some branches, as superior teachers.

The staff of the school consists of a Director for both departments; with a sub-director, manager and thirteen professors for the girls' school; and a manager, general superintendent, assistant superintendent, two honorary professors, and thirty-four professors and assistants for the boys' department. The assistants constitute a division of masters in training, and form an integral part of the organization for teaching as well as for disciplinary purposes.

In regulating the admissions to the school, preference is given to the children of poor parents, and no charge is made

even for materials. The aim of the school has already been stated. The workshop instruction is only carried to such point as will make it preparatory to after training, and in this way more time is allowed for development of the theoretical studies.

The school hours are from 7.45 A.M. in winter, and 7.15 A.M. in summer, until 7 P.M., with an intermission from 11.50 A.M. until 2 P.M. On Thursday there is only a morning course for scholars of the third year, and nothing for those of the first and second years. If there is added to the above, the time necessary for duties at home which almost always take several hours in the evening, it is evident that the pupils have very long and continuous employment, and it has been a serious question with the administration of the school whether this would be prejudicial to their health. It was on this account that a few years ago, all work was discontinued on Thursdays except for the third year..

The method of instruction adopted in most of the courses at la Martinière is peculiar, and this is believed to be one of the principal causes of the success of the school. The system is that of M. Tabareau, originally framed for courses in mathematics and subsequently adopted under his inspiration, to other important studies. It devises a means by which an ordinary professor is capable of taking charge of a very large class of pupils and keeping them all employed without one of them ceasing for an instant to have his attention diverted from his work.

Lessons are never taught in this school by a purely oral method and the voice of the teacher is constantly and intimately mingled with the personal work of the pupils.

M. Tabareau's method of teaching mathematics and physics, possesses a number of advantages. It provides a ready acceptation of work by all the pupils at once, allows a considerable amount to be done rapidly without fatigue, incites emulation among the pupils, and develops enormously the faculty of attention.

The essential part of the system involves simultaneous calculations by all of the class, and to properly carry this out, it is necessary:

(1) To distribute to the scholars tables on which the different methods of calculation are condensed in a few lines.

(2) To isolate the individual work of each scholar so as to prevent copying of results from neighbors.

(3) To adopt some very concise mode of dictation, so as to reduce to a minimum the time necessary for dictating the successive exercises.

(4) To arrange for an immediate and rapid verification of the work of all the pupils after each exercise, before passing to the next.

The first three requirements have been complied with, as much by a particular distribution of the calculation tables, as by the division of the scholars into a certain number of series, each of which shall have different data to work upon, this variety of data being arranged so as not to increase the time of the dictation. To meet the fourth requirement, M. Tabareau furnishes the pupils with special appliances in the way of wooden tablets or slates and arranges an extremely simple way of using them.

Large classes of seventy or eighty pupils are conducted by one teacher with the help of one assistant. Questions are put to the class and answers taken either orally from such scholars as the teacher may select, or collectively in writing, on the small slates or blackboards which the scholars have. These are then collected by the assistant and the teacher glancing rapidly over them, readily and quickly detects any errors. In teaching arithmetic or algebra a series of questions are given out on slips of paper and the work is performed on one slate, the scholar transcribing on a second slate one or more answers to selections arbitrarily made by the teacher, these answering slates being afterwards collected and examined.

Other appliances have been devised by M. Tabareau for the teaching of descriptive geometry and geometry of solids.

In the analytical parts of elementary mathematics, M. Tabareau's system is departed from only when the student, having overcome the difficulties of calculation, is

able to comprehend more easily a demonstration free from all these impediments. In geometry it is considered that the teaching is much simplified by appealing in the beginning to the intuition of the pupils and teaching intuitively before bringing up the difficulties of demonstration.

The system of teaching drawing at la Martinière is that organized in 1833 by M. Louis Dupasquier, architect, and professor at the school from 1828 until 1854. This gentleman was materially aided in his work by M. Monmartin who was connected with the Administrative Commission of the school at that time, and to him is due the honor of introducing the use of slates by the pupils, one of the great causes of the success of the method.

M. Dupasquier interdicted absolutely the copying of drawings, engravings, or objects in the flat, and commences with elementary lessons in linear perspective, confining the pupil to the question of parallelism of lines and the development of surfaces. The pupil next advances to the study of relief models and the making of models, exercising simultaneously the eye, the hand and the intelligence, and solving practically the elements of perspective. This part of the study is finally completed with the models, by means of which, through a simple conception, most of the difficulties to be solved in perspective, can be presented. M. Dupasquier's really original and successful method does not consist merely in the use of slates, the employment of special models and the bold conception of commencing, even for young children, with the study of perspective, but it comprises in particular, modes of general study through which unfortunately, most efforts in courses of this nature fail. The course of study in drawing at la Martinière is really a class course, not as in almost all parallel cases an atelier course.

It was in 1843, after designing special appliances for the use of pupils in the drawing-room, and arranging the disposition of the students in circles that M. Depasquier was able to give his course its full development in the shape that it is still taught at la Martinière, showing facility in its application and maintaining among the students that spirit

of order and work that is not often found among boys. Pupils of twelve to fourteen years of age who have never been taught drawing before, are instructed by a two-years' course, in free-hand perspective, in linear perspective, in projection, and in the application of shading and washes to perspectives of considerable complication.

During the past few years there has been added to this course a third year, in which shading, linear perspective, architectural design, and finally machine drawing, freehand as well as mechanical, are taken up and completed.

The drawing-room is about 140 x 45 feet in size, and it is divided into sections by screens, the boys being arranged in circles around the object to be drawn, seated on stools which have a back that can be inclined to any desired angle necessary to support the slate or blackboard. Pupils draw at first on the slate only, thus facilitating correction and avoiding waste of paper. This cannot but give a freedom of hand in execution, far beyond what can be obtained on paper. The pupils beginning with outline regular figures constructed of stout wire, pass on to skeleton solids and then to block architectural models. In the advanced classes, drawings are made from parts of machines and scientific instruments. A course of modelling in clay is given during the first year, and it is a valuable auxiliary to the drawing course, familiarizing the pupil at the beginning with forms and reliefs.

When manufactories are visited, the students are obliged to write out full accounts of their visits, and much attention is paid to this department of the course.

The girls' school was not organized until 1879, and the course of instruction is somewhat different from that of the boys, embracing grammar, history and geography, mathematics, designs, writing, the usual sciences and domestic economy, for the general studies; while special studies comprise industrial design, commercial courses in writing, book-keeping and English, and manual work. The general instruction is obligatory for all pupils. The special instruction is given in three divisions:

(1) The commercial department.

(2) Industrial design, in which special attention is paid to designing patterns for lace, silk and embroidery.

(3) That of dress-making and fine needlework.

Choice can be made of either of these divisions. The general studies are in the morning and the special work in the afternoon.

M. Bouvet, President-elect "École la Martinière," stated in his address at the annual distribution of prizes, for the year 1887–88, that the school year would commence with 577 pupils in the department of boys, of which 318 would be in the first year, 164 in the second year and ninety-five in the third, the total being the maximum number which this department of the school could receive. Also, that in the department for girls there would be seventy pupils in the first year, fifty-four in the second and thirty-six in the third with one special student in the course of design, making a total of 161. The total for boys and girls for that year, therefore, was 738.

M. Bouvet called attention to the increased facilities given in the course for chemistry, a science which was every year taking a more important place in modern industries. He stated that the course had been put into harmony with the now accepted theory of the science, by the adoption of the atomic theory of notation to the entire exclusion of that of equivalents, and that the laboratories and classes had been completely rearranged in accordance with experience gained from visits and examination of a number of schools of chemistry of the highest repute in Europe, also that a special room had been set apart to provide for a material development of individual manipulations and investigations by the students, a subject of the highest importance for their instruction, in the present advanced state of the science. He considered that the installation for chemistry was not now excelled by anything either in France or foreign countries.

Analogous efforts had been made with the course in natural sciences, but here everything had to be practically created, as very little in this course had previously existed at la Martinière. Hardly a year had passed since there was

nothing in the way of collections, but a thorough reorganization had been effected, and collections of real importance added to the museum without cost to the school, through donations from the collections of the city, and through the indefatigable zeal that the professor in charge of this department, M. le Docteur Roux had put in the work.

In reference to the methods of teaching employed in the school, M. Bouvet stated that the experience of half a century has proved their efficacy, and the greatest prudence should be exercised in making any changes, the preferable position to take being one midway between disastrous immobility and dangerous innovations. Every day new testimony was received that the methods of teaching responded well to the end sought, this end being to give to the children a good general instruction, at the same time both theoretical and practical, permitting them to succeed later in any career, industrial or commercial, to which their adaptability, the preference of their parents, or the simple hazard of life might lead them. He thought that the just preponderance given to the various subjects in the course of study, together with the particular activity of mind which the methods of teaching developed, have had the result of making the scholar apt to turn his hand, and to succeed in whatever employment or profession his life might lead him.

M. Bouvet dwelt upon the importance of having the scholars of the third year make visits to various kinds of manufactories, mechanical and chemical works, etc., and stated that the reports of these visits, presented by the pupils, showed that they bore good fruit. They gave excellent opportunity to the scholar to apply knowledge gained in his courses of study and at the same time brought out individual characteristics which failed to appear from the school work.

Great stress was laid by M. Bouvet on the education of the student in habits of politeness, good deportment, cleanliness, and above all, sentiments of duty. He believed that these questions should come before even those of instruction proper, because they laid a great foundation or capital

for the future interests of the scholar. When a child is inspired with proper notions of goodness and justice, it is much easier to make a man of him than when he is merely taught an idea in geometry or algebra. Besides, one forgets very easily, soon in life, the greater part of what one has learned in theoretical studies, but the habits of work, of discipline, of dignity, of respect for oneself and others, the sentiments of loyalty and the healthy fellowship of patriotism, which can and should be fostered in the child, really make a moral imprint which can never be effaced. M. Bouvet had the satisfaction of stating that the efforts in this direction were crowned with success, proof of it being given daily, either among the scholars individually or collectively, or in those who have graduated at the school. Military discipline contributes much to help these healthy habits of moral education, of fellowship and of patriotism. A certain number of the students after graduation continue their studies in schools of higher grade than la Martinière, benefiting by the funds, which are generally put at their disposal by the Municipal Council, the General Council and the Chamber of Commerce. These funds are the highest rewards that can be accorded to the more meritorious students, because they offer them a means of greater instruction and an opportunity of reaching in the future a better position in life. These students always take a high standing in the schools which they attend, thus furnishing the best testimony as to the good results of the work and methods of la Martinière.

That habits of industry and study are deeply engrafted in the minds of the pupils, is constantly shown from the fact that most of those who graduate and subsequently become employed in business, continue studies in applied sciences, modern languages, etc., by self-instruction.

M. Bouvet stated that the department for girls did not show the advancement of that of the boys, owing to the defective location which it occupied. That it had a reputation among the people of Lyons was shown by the facility with which graduates found employment, but all new development was checked by the insufficiency of its instal

lation. When the day came however that "la Martinière des Filles" could be properly installed, it would have nothing to envy in the prosperity of "la Martinière des Garçons."

It was expected to develop in the school for girls a department of older scholars, which now had only an incidental place, so that those students who had passed through the regular three years' course might continue to come to the workshops for the purpose of perfecting themselves in the trades which they had selected, executing under the direction of the professors, without charge, any work for which they had orders, and for which they would receive the whole pay. It would be a great advantage for them to continue to receive the advice of their superiors, and it was thought that considerable good would also result from their intercourse with the new pupils. M. Bouvet expected that this department would be specially utilized by a considerable number of students from the section in embroidery, a very important section of the school, and one of great benefit to the embroidery industry of Lyons, as it furnished every year a certain number of intelligent workmen, whose talent would enable it to struggle successfully against outside competition.

Concerning the methods of teaching, M. Bouvet further remarks that every year the two schools, especially that of the boys, receive visits from a great number of persons, not only of France, but from abroad, who are always very much impressed with the originality of the special methods of teaching adopted. These methods, which have been in operation for fifty years, now begin to attract attention from outside, and not only is this perceived from questions with regard to them from all quarters of the globe, but what is better, they are being imitated. The reform, which has taken place in the methods of instruction in drawing in the French schools, has been strongly inspired by the system taught here, and the schools of Lyons are beginning to benefit from it even more directly than those elsewhere, owing to the normal course in design which has been created by the city at la Martinière for the purpose of educating public teachers. It is regretted, however, that a gen-

eral reform in methods of teaching in other branches of the courses of primary instruction in the schools of the country has not taken place, particularly in mathematical courses. This anomaly will, however, disappear, because of the initiative taken by the eminent Director of primary education to the Minister of Public Instruction, M. Buisson. The Minister has in fact decided, on M. Buisson's recommendation, that a certain number of those learning to be teachers, in the normal school of Lyons, shall be authorized to form a fourth-year course at la Martinière for the purpose of being instructed in the peculiar methods of teaching there adopted. In consequence of this arrangement it is certain that the method of Tabareau will find its way into the primary schools of Lyons, and little by little eventually in the other schools of France, producing the same results that long experience has shown at la Martinière.

[*To be continued.*]

THE IVES PORTABLE PROJECTING LANTERN.

[*Report of the Committee on Science and the Arts.*]

[No. 1479.] HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, October 23, 1889.

The Sub-Committee of the Committee on Science and the Arts, constituted by the FRANKLIN INSTITUTE of the State of Pennsylvania, to whom was referred, for examination,

THE IMPROVEMENTS OF FREDERICK E. IVES, IN THE PROJECTING LANTERN AND ITS APPURTENANCES,

Report that: They have examined the apparatus as arranged, the object of which may be thus described:

The projecting lantern is pre-eminently an educational instrument, the places of exhibition constantly changing. In a few instances, as in the case of the fixed lecture-room of a college, bulk and weight are of no great moment, but in the great majority of cases, the apparatus must be moved to the place of exhibit and taken away at its close. In such

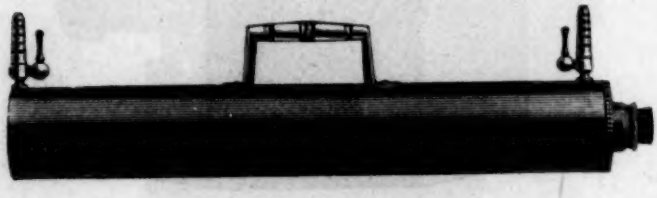
cases, weight and bulk become most important items. It has for years been the study to reduce the weight and bulk of the apparatus, as the older forms made a heavy load to handle.

Mr. Ives presented to your sub-committee, the apparatus in two items, viz: the projecting lantern itself, and his method of producing light.

We consider first the light.

In Mr. Ives' patented arrangement, he dispenses with the weight and bulk of the hydrogen cylinder, or bag and press-board, thus transporting one gas-holder instead of two.

Instead of hydrogen, as the combustible in the jet flame, he passes a small stream of oxygen through a small metal cylinder, containing a porous filling saturated with ether, then on to the ordinary jet, when it is mixed with the

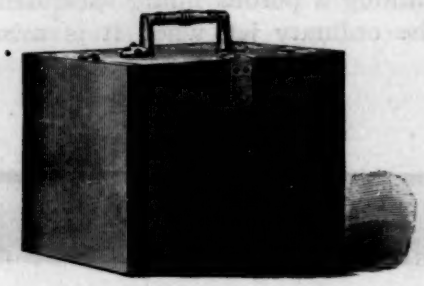


blast stream of oxygen. The details of the invention are set forth in the accompanying patent specifications and drawings.

It is sufficient to say that this small metal cylinder is completely filled with a rolled cylinder or wad of soft cotton cloth, cut so as to form a small canal on its upper surface, when in place in the metal cylinder, which canal is not in a straight line from end to end, but zigzag, so as to form a canal two or three times longer than if the channel were straight, compelling the gas to take more time in passing through, and thus insuring more perfect saturation of the oxygen with the ether vapor.

The sub-committee carefully compared the light given by the Ives ether light with that of the best oxyhydrogen apparatus, by throwing the two lights, each upon half of the screen at the same time, and believe the two to be equal in intensity.

Both sulphuric and petroleum ether were tried, the opinion of the Committee from observation being that the petroleum ether gave perhaps a whiter light. Petroleum ether possesses the advantage that it leaves no residuum, while sulphuric ether gives a residuum of alcohol and water, which in time take the place in the cylinder which should be occupied by ether only, and make it necessary occasionally to remove and dry out the cotton roll. An advantage appears to be with the ether-oxygen over the oxyhydrogen mixture, in that it gives upon the lime a smaller surface of incandescence, and as the principle upon which condensers are constructed is based upon the idea of the light emanating from a point, it would seem that the smaller the incan-

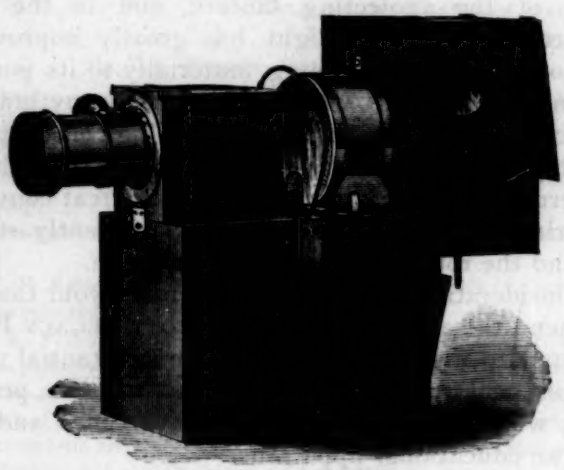


descent spot (other things being equal) the sharper the definition.

The question of danger was elaborately discussed. Under its first form, namely, bubbling the gas through a wash-bottle half filled with ether, the apparatus certainly was dangerous, because that method did not positively insure a non-explosive mixture, and in case of accidental removal of pressure of gas supply the mixture was liable to explode back into the wash-bottle, bursting it and throwing burning ether about the room. In the Ives saturator a non-explosive mixture is produced under normal conditions, and even if from any cause, such as an unusually low temperature or a deficient supply of ether, an explosive mixture be produced, the quantity would be so small that the worst effect of an explosion would be to blow the cork from the end of the tube or blow the rubber tubes from the nipples.

The "folding lantern" was exhibited in both single and double forms, there being nothing new in the principle of the lantern itself, but only in the plan of construction, which permits of the folding and sliding of the parts upon another in such manner as greatly to reduce bulk of apparatus, when packed for carriage; the single lantern being disposed in a box 8⅛ inches long, 6 inches wide, and 6½ inches deep, and weighing about 8 pounds.

On sliding out the top or lid, the condenser is found securely fastened to its under side. The frame carrying the objective is also secured to the lid by bayonet hinges



and folds back close to the condenser. When the hinged piece carrying the objective is turned open to its provided limit, we have the condenser and objective in a true axial line, without needing further adjustment. The reversed lid is now slid into the top of the box which becomes the base of the lantern. The jet is then fastened in its place and a sheet-iron hood, which is made of the proper dimensions exactly to slide into the box from the open or back end, is affixed to its place over the jet. The frame of the objective has wings of sheet-iron hinged to the top and sides, forming, when opened, screens to prevent side dispersion of the light. The sheet-iron hood has likewise hinged doors, which

close flat when packed and open when in position to prevent diffusion of light into the room. The removal of the hinged front-piece, carrying the objective, leaves an open platform upon which such lantern attachments as the microscope, polariscope, etc., may be fastened.

By a simple device the lantern is securely attached to the top of the oxygen cylinder, thus having a firm and compact base, which obviates the necessity of providing a separate stand or table.

It appears to your sub-committee that Mr. Ives, both in respect of the design and construction of the mechanical portion of the projecting lantern, and in the method employed for producing light, has greatly improved this educational apparatus, adding materially to its portability and general handiness, without sacrificing anything of its efficiency. In short he has produced a high-class apparatus of notably small bulk and weight compared with the forms of lanterns heretofore known and used, of great convenience for carriage and manipulation, yet sufficiently strong to withstand the rough usage of transportation.

In consideration of the foregoing facts, your Committee recommend the award of the JOHN SCOTT LEGACY PREMIUM AND MEDAL to Mr. Frederick E. Ives, for substantial improvements in construction and operation of the projecting lantern, which have added to its convenience and usefulness as an educational apparatus.

Respectfully submitted,

EDWARD F. MOODY, *Chairman*,
SAMUEL SARTAIN,
[SIGNED] N. H. EDGERTON,
H. PEMBERTON, JR.,
H. R. HEYL.

Adopted November 6, 1889.

S. LLOYD WIEGAND,
Chairman of the Committee on Science and the Arts.

PROCEEDINGS

OF THE

CHEMICAL SECTION,

OF THE

FRANKLIN INSTITUTE.

[*Stated Meeting, held at the* INSTITUTE, *Tuesday, Feb. 18, 1890.*]

HALL OF THE FRANKLIN INSTITUTE.
PHILADELPHIA, February 18, 1890.

Mr. T. C. PALMER, President, in the Chair.

Members present: Profs. Sadtler, Smith, Trimble, Drs. Hooker, Keiser, Keller, Wahl, Messrs. Rowland, Macfarlane, Palmer, W. H. Bowers, Williams, Frankel, Galt, Jayne and four visitors.

Mr. Edw. K. Stevens, Forty-second and Locust Streets, was nominated for membership.

The resignation of H. N. Rittenhouse was presented, and on motion accepted.

Dr. E. H. Keiser presented a paper "On the Synthesis of Fumaric Acid," which was referred for publication in the JOURNAL.

Prof. E. F. Smith presented a paper on the electrolytic method as applied to palladium. (Referred for publication.) After the reading of the paper Prof. Smith exhibited six platinum dishes, containing, respectively, depositions of palladium, silver, nickel, cadmium, mercury and iron, obtained by the electrolytic methods described by him in this and former papers.

Dr. Hooker spoke of the compound obtained from pyrrol by picric acid. On heating a mixture of equal molecules of the two at 58° to 60° until the picric acid is dissolved and cooling rapidly, long red needles crystallize out, which were rapidly dried by pressure between filter paper. If the mixture be heated above 60° the compound is not obtained. The method of analysis employed consisted in exposing a weighed quantity to the air and weighing again. This was repeated until weight became constant. The loss represented the pyrrol evaporated. The residue showed the melting-point of picric acid. Theory required 22·6 per cent. pyrrol for a compound of equal molecules of picric acid and pyrrol. Obtained 22·6, 22·7 and 22·9 per cent. loss.

Dr. Keller then presented a paper on Symmetrical Tetrabromacetyl, which was referred for publication.

At the conclusion of the meeting, the election of Mr. Edw. Stevens, as a member of the Section, was announced.

The meeting then adjourned. H. W. JAYNE, *Secretary pro tem.*

ELECTROLYTIC SEPARATIONS.

By Edgar F. Smith and Lee K. Frankel.

[*Read at the Stated Meeting of the Chemical Section, held December 17, 1889.*]

The study of the electrolysis of the double cyanides of cadmium, copper and zinc, enabled us to formulate conditions, by which the separations of cadmium from zinc (*American Chemical Journal*, **11**, 352,) and cadmium from copper (*Journal of Analytical Chemistry*, **3**, 385,) were possible, and in every particular satisfactory.

The ease with which cadmium was separated from zinc, and the very close results obtained with these metals, led us to apply the method to the separation of cadmium from cobalt and from nickel. Operating first with cadmium alone, we dissolved sufficient pure sulphate in water, so that 10 cc. of the solution would contain 0·1688 gram metallic cadmium. To this volume (10 cc.) were added four and one-half grams pure potassium cyanide, and the solution made up to 200 cc. with water. A current yielding 0·4 cc. O-H gas per minute, was allowed to act upon the same for a period of fourteen hours. The deposited metal weighed 0·1686 gram, a difference of −0·11 per cent. from the theoretical. A second trial, with conditions precisely analogous to those just mentioned, gave 0·1690 gram cadmium, a difference of + 0·11 per cent. from the theoretical.

CADMIUM FROM COBALT.

In the third experiment the conditions were the same as before, with this difference, that an equal amount of cobalt was also present in the solution. The result of the electrolysis was 0·1689 gram cadmium, a difference of + 0·05 per cent. from the required.

The fourth experiment, similar in every way to the third yielded 0·1689 gram cadmium, a difference of + 0·05 per cent. from the theoretical.

The cadmium was fully deposited on both occasions, and contained no cobalt.

CADMIUM FROM NICKEL.

Passing to the separation of cadmium from nickel, the results were so surprising, that we give the same in detail, although negative in character.

	Cadmium present in grams.	Nickel present.	Potassium Cyanide in grams.	Total dilution.	Strength of current in cc. O-H gas per minute.	Cadmium found.
1	0·1688	100 %	4½	200 cc.	0·3 cc.	0·1717
2	"	"	"	"	"	0·1702
3	"	"	"	"	"	0·1725
4	"	"	"	"	"	0·1750
5	"	"	"	"	"	0·1721
6	"	"	"	"	"	0·1737
7	0·1828	—	"	"	0·5 cc.	0·1827
8	"	75 %	"	"	"	0·1923
9	"	50 %	"	"	0·15 cc.	0·1841
10	"	"	"	"	0·5 cc.	0·1882
11	"	25 %	"	"	0·15 cc.	0·1854

The period of time during which the current acted in each of the above experiments was sixteen hours. Nickel was always found in the cadmium deposit, while in many cases the precipitation of the cadmium was incomplete. The conditions were varied, yet the results were wholly unsatisfactory. By greatly increasing the quantity of cyanide, we discovered that the cadmium precipitation was retarded. Nickel when alone, and when under the conditions given above, would not deposit with the strength of current used by us. This behavior is only another indica-

tion, that if we would make electrolytic methods widely applicable, it is first necessary to extend the study of the action of the current to all the salts possible, and to investigate carefully the influence of each metal upon its associates under varying conditions.

From what we have thus far accomplished, we find the electrolytic separation of cadmium from copper, from zinc, and from cobalt, in cyanide solution, all that could be expected from any method. The cadmium deposits, in the experiments recorded in this paper, were always washed with boiling water; the drying was done upon the edge of a warm iron plate.

We have already called attention (*American Chemical Journal*, **11**, 264,) to the fact that mercury is fully precipitated from the solution of its double cyanide by a comparatively feeble current, and that the separation of this metal from copper is possible, so long as the quantity of the latter does not exceed twenty per cent. of the mercury present.

More recently we have executed a series of experiments looking to the separation of mercury from zinc, nickel and cobalt.

MERCURY FROM ZINC.

The results with these metals are:

	Mercury present in grams.	Zinc present.	KCN in grams.	Total dilution.	Current strength in cc. O.H gas per minute.	Mercury found.	Difference in % from theoretical.
1	0·1715	—	4½	200 cc.	0·3 cc.	0·1717	+ 0·12 %
2	"	—	"	"	"	0·1715	—
3	"	100 %	"	"	0·25 cc.	0·1706	— 0·52 %
4	"	"	"	"	"	0·1709	— 0·34 %

The time in each deposition was sixteen hours. From these figures the separation is possible. Mercury was not found with the zinc. In the following experiments it will be observed that the error is much less, and accordingly

makes the method trustworthy, and from its accuracy, well-suited for scientific as well as technical work:

	Mercury present in grams.	Zinc present.	KCN in grams.	Total dilution.	Current strength in cc. O H gas per minute.	Mercury found.	Difference in % from the theoretical.
5	0·2440	100 %	3	200 cc.	0·5 cc.	0·2435	— 0·20 %
6	"	"	3	"	"	0·2445	+ 0·20 %
7	"	"	4½	"	"	0·2441	+ 0·04 %
8	"	"	"	"	0·28 cc.	0·2445	+ 0·20 %
9	"	"	"	"	"	0·2431	+ 0·37 %
10	"	"	"	"	"	0·2454	+ 0·50 %

The time of precipitation, made at the ordinary temperature, amounted to sixteen hours. The mercury deposit was washed with hot water, and dried upon a moderately warm iron plate.

MERCURY FROM NICKEL.

With these two metals the current was allowed to act for sixteen hours. The results are as follows:

	Mercury present in grams.	Nickel present.	KCN in grams.	Total dilution.	Current strength in cc. O-H gas per minute.	Mercury found.	Difference in % from the theoretical.
1	0·2440	100 %	4½	200 cc.	0·4 cc.	0·2435	— 0·20 %
2	"	"	"	"	"	0·2432	— 0·32 %
3	"	"	"	"	"	0·2425	— 0·60 %

MERCURY FROM COBALT.

Our experience with these two metals was so unexpected that we append the poor as well as the good results which were finally obtained:

	Mercury present in grams.	Cobalt present.	KCN in grams.	Total dilution.	Current in cc. O-H gas per minute.	Mercury found.	Difference in % from the theoretical.
1	0·2440	100 %	4½	200 cc.	0·4 cc.	0·2386	— 2·21 %
2	"	"	"	"	"	0·2388	— 2·13 %
3	"	"	"	"	"	0·2364	— 3·11 %
4	"	"	"	"	"	0·2333	— 4·00 %
5	"	"	"	"	"	0·2366	— 3·02 %

The current acted for sixteen hours, upon reducing the quantity of cobalt, and operating with the conditions, in other respects, the same as before (except in 11 and 13), we obtained:

	Mercury present in grams.	Cobalt present.	KCN in grams.	Total dilution.	Current in cc. O-H gas per minute.	Mercury found.	Difference in % from the theoretical.
6	0·2440	75 %	4½	200 cc.	0·5 cc.	0·2353	— 3·56 %
7	"	"	"	"	0·86 cc.	0·2357	— 3·40 %
8	"	50 %	"	"	0·5 cc.	0·2387	— 2·25 %
9	"	"	"	"	"	0·2381	— 2·33 %
10	"	"	"	"	0·86 cc.	0·2321	— 4·80 %
11	"	25 %	3	"	0·5 cc.	0·2442	+ 0·09 %
12	"	"	4½	"	0·86 cc.	0·2342	— 4·01 %
13	"	12½ %	3	"	0·5 cc.	0·2445	+ 0·20 %

Inspection of these figures discloses the fact that nothing approaching a separation of the two metals appears probable until in experiment (11), where not only the quantity of cobalt is reduced, but also that of the potassium cyanide. The result is then surprisingly close (+·09 per cent.). This would seem to be due rather to the reduction of the quantity of cyanide, inasmuch as by its increase in experiment (12), we again have a minus error of 4·01 per cent.,

and in experiment (13), by reducing the quantity of cyanide to three grams, the result is satisfactory. As the quantity of cobalt, in this instance, was but half of that in experiment (12), the favorable result might be attributed to this. Hence, the following trials were made:

	Mercury present in grams.	Cobalt present.	KCN in grams.	Total dilution.	Current in cc. O-H gas per minute.	Mercury found.	Time of precipitation.	Difference in %.
14	0.2250	—	3	200 cc.	0.5 cc.	0.2250	16 hours.	—
15	"	25 %	"	"	"	0.2256	"	+ 0.26 %
16	"	50 %	"	"	"	0.2258	"	+ 0.35 %
17	"	75 %	"	"	"	0.2258	"	+ 0.35 %
18	"	100 %	2.2	"	"	0.2235	"	— 0.60 %

Cobalt was not found in the mercury deposit, nor mercury in the cobalt solution.

Evidently the quantity of cyanide present exercises a marked influence upon the separation. Returning to the separation of cadmium from cobalt, it will be observed that the amount of cyanide present there, was four and a half grams, while the quantity of metal was less, yet the separation proved satisfactory.

SILVER FROM COPPER.

It yet remains for us to record some experiments upon the separation of these two metals in cyanide solution. Reference to a former paper (*American Chemical Journal*, **11**, 264, and *Journal of Analytical Chemistry*, **3**, 254,) will show that our attempts in this direction were at that time fruitless. It was after the successful separation of cadmium from copper in cyanide solution that we were impressed with the idea that the separation of silver from copper ought to occur, since silver deposits so readily, even when exposed to a very feeble current. In the communication to which we refer, the current strength recorded was

1 cc. O-H gas per minute. Since it was, by carefully reducing this in other cases, that we obtained good separations, we instituted a new series of experiments with silver and copper, acting upon the mixture with a much weaker current:

	Silver present in grams.	Copper present.	KCN in grams.	Total dilution.	Current in cc. O-H gas per minute.	Time in hours.	Silver found.	Difference in %.
1	0·1788	—	4½	200 cc.	0·10 cc.	16	0·1792	+ 0·22 %
2	"	—	"	"	0·23 "	"	0·1788	—
3	"	100 %	"	"	0·15 "	"	0·1788	—
4	"	"	"	"	0·30 "	"	0·1787	— 0·05 %
5	"	"	"	"	0·20 "	"	0·1784	— 0·20 %
6	"	"	"	"	" "	"	0·1782	— 0·33 %
7	"	"	"	"	0·40 "	"	0·1783	— 0·28 %
8	"	"	"	"	0·15 "	"	0·1800	+ 0·60 %

We next dissolved 0·1732 gram pure metallic silver in nitric acid. To its solution, after evaporation, there were added 100 per cent. copper and four and a half grams potassium cyanide. On electrolyzing, with a current of 0·15 cc. O-H gas per minute, the resulting silver weighed 0·1725 gram. The latter contained no copper, nor could silver be detected in the copper solution.

A silver ten-cent piece, weighing 1·2236 grams, was brought into solution and diluted to 100 cc. Of this solution, two portions (25 cc. each) were electrolyzed in the presence of four and a half grams potassium cyanide, with a current of 0·4 cc. O-H gas per minute. The silver found was in:

(*a*) 89·64 per cent.
(*b*) 89·56 per cent.

Two silver determinations made with another coin gave:

(*c*) 89·44 per cent.
(*d*) 89·44 per cent.

A silver dime, weighing 2·4507 grams, carefully cleaned with sodium hydroxide and alcohol, after solution in nitric acid, and the expulsion of the excess of the latter, was electrolyzed with a current of 0·7 cc. O-H gas per minute, in the presence of seven grams potassium cyanide, and gave 2·1996 grams silver = 89·79 per cent.

So far as we are aware, this is the first electrolytic method, which has been proposed for the separation of these two metals.

SILVER FROM ZINC.

No difficulty is experienced in separating these metals when in cyanide solution. Our results are as follows:

	Silver present in grams.	Zinc present.	KCN in grams.	Total dilution.	Current in cc. O-H gas per minute.	Time in hours.	Silver found	Difference in %.
1	0·1788	100 %	4½	200 cc.	0·23 cc.	16	0·1784	— 0·22 %
2	"	"	"	"	0·40 cc.	"	0·1785	— 0·11 %
3	"	"	"	"	"	"	0·1779	— 0·50 %
4	"	"	"	"	"	"	0·1787	— 0·05 %

Applying the same procedure to the separation of

SILVER FROM NICKEL,

the results obtained were equally as good:

	Silver present in grams.	Nickel present.	KCN in grams.	Total dilution.	Current in cc. O-H gas per minute.	Time in hours.	Silver found.	Difference in %.
1	0·1788	100 %	4½	200 cc.	0·35 cc.	16	0·1785	— 0·16 %
2	"	"	"	"	"	"	0·1778	— 0·50

SILVER FROM COBALT.

The following are the results obtained:

	Silver present in grams.	Cobalt present.	KCN in grams.	Total dilution	Strength of current in cc. O-H gas per minute.	Time in hours.	Silver found.
1	0·1788	100%	4½	200 cc.	0·35 cc.	16	0·1728
2	"	"	"	"	"	"	0·1747
3	"	"	"	"	"	"	0·1758
4	"	"	"	"	"	"	0·1697

Recalling our experience in separating mercury from cobalt, we reduced the quantity of cyanide to three grams, and obtained:

	Silver present in grams.	Cobalt present.	KCN in grams.	Total dilution.	Current in cc. O-H gas per minute	Time in hours.	Silver found.	Difference in %.
5	0·1788	100%	3	200 cc.	0·35 cc.	16	0·1794	+ 0·33%
6	"	"	"	"	"	"	0·1782	— 0·33%

From experiments made to learn the action of the current upon solutions of cobalt in the presence of a great excess of potassium cyanide, we know that the higher cyanide of cobalt—the cobalticyanide—is produced, and may it not be this, which in some manner combines with the last traces of mercury and silver to form double cyanides not decomposable by the current strength employed in our experiments, which, if increased, would throw out not only the mercury and silver, but also some cobalt?

With cadmium, the double compound, if formed, may be more readily broken up, hence the separation is easily made. By reducing the quantity of potassium cyanide with mercury and silver, we afford no opportunity for the production

of cobalticyanide in such quantity as to appreciably affect the deposition of the other metals.

COPPER FROM CADMIUM IN THE PRESENCE OF SULPHURIC ACID.

From the fact that it is possible to precipitate cadmium completely from the solution of its sulphate, containing free sulphuric acid (Smith, *American Chemical Journal*, **2**, 42), and as copper is also deposited under similar conditions, the separation of these metals, when in this form, would hardly be expected. The experiments given below, show that notwithstanding all this, their separation can be effected under the conditions indicated. The first results were negative:

Ten cc. copper sulphate (0·1975 gram metallic copper, 10 cc. cadmium sulphate (0·1828 gram metallic cadmium), 1 cc. H_2SO_4 (sp. gr. 1·09) with 150 cc. water were electrolyzed with a current generating 0·4 cc. O-H gas per minute. The copper was fully precipitated, and with it considerable cadmium.

In a second series of three experiments, similar to that above, excepting that the current only gave 0·22 cc. O-H gas per minute, the copper was entirely precipitated, but carried down some cadmium with it.

In a third series of three experiments, the sulphuric acid in each dish was increased to 5 cc. (sp. gr. 1·09). The current gave 0·22 cc. O-H gas per minute. The copper was not completely precipitated, and cadmium had deposited on the copper.

The fourth series was made up as follows:

(1) 10 cc. copper sulphate = 0·1975 gram copper.

10 cc. cadmium sulphate = 0·1828 gram cadmium.

10 cc. H_2SO_4 (sp. gr. 1·09.)

100 cc. water. Current = 0·3 cc. O-H gas per minute. Time, 12 hours. The copper deposit weighed 0·1968 gram.

(2) Same as (1), copper found = 0·1964 gram.

(3) 10 cc. cadmium sulphate = 0·1828 gram cadmium, 5 cc. H_2SO_4 (sp. gr. 1·09). 100 cc. water. Current as in (1) and (2). Cadmium was not precipitated.

In the fifth series of four experiments, a current genera-

ting 0·5 cc. O-H gas per minute was employed. The quantity of acid was increased to 10 cc. and 15 cc. cadmium separated together with the copper.

The sixth series included five experiments:

(1) 10 cc. copper sulphate = 0·1975 gram copper.
10 cc. cadmium sulphate = 0·1828 gram cadmium.
15 cc. H_2SO_4 (sp. gr. 1·09.)
100 cc. water. Current = 2 cc. O-H gas per minute.
Copper found = 0·1969 gram copper.

(2) Same as (1), gave 0·1976 gram copper.

(3) Same as (1) and (2), except that the current generated 0·3 cc. O-H gas per minute. Copper found = 0·1975 gram.

Experiments (4) and (5) were like (3). The copper deposited equalled 0·1969 gram and 0·1962 gram. Tabulating the results, we have:

	Copper required.	Copper found.	Difference in %.
1	0·1975	0·1968	−0·35
2	"	0·1964	−0·55
3	"	0·1969	−0·30
4	"	0·1976	+0·05
5	"	0·1975	—
6	"	0·1969	−0·30
7	"	0·1962	−0·65

The filtrates from the deposited copper were examined for that metal. (7) showed a trace of copper. Cadmium was not detected in the precipitated metal. Holding strictly to the conditions given above, will enable any one to effect the separation of these two metals in the presence of sulphuric acid.

UNIVERSITY OF PENNSYLVANIA,
January 6, 1890.

THE ACTION OF CHLORINE ON HÆMATOXYLIN AND THE EXTRACTIVE MATTER OF LOGWOOD.

By WM. W. MACFARLANE and PHILIP S. CLARKSON.

[*Read at the Stated Meeting of the Section, January 21, 1890.*]

It is well-known among dyers, who have had any experience in extracting the coloring matter from logwood by boiling the wood under pressure in closed vessels, that a larger quantity of wood, when so treated, is required for dyeing a given quantity of material, than when the coloring matter is extracted by boiling the wood in an open vessel, such as a dye tub. It was the desire to discover the cause of this difference, and to avoid the loss of coloring matter, that led to a long series of experiments, and the discovery that chlorine can be used to increase the dyeing power of the extractive matter of logwood; and also that hæmatoxylin and hæmatein have entirely different values for the dyer, depending upon the manner in which they are used; that is, whether used for coloring wool or cotton, and whether the dyeing is done in an acid, alkaline or neutral bath.

Logwood, before it is used by the dyer, is treated by a process called "curing," which consists in saturating the chipped or ground wood with water, then allowing it to lie in heaps or beds until a kind of fermentation or heating takes place. It is then necessary to move it frequently to avoid any considerable increase in temperature, and to expose all portions of it to the oxidizing influence of the air. Exactly what takes place in this curing process is not known, as the composition of the extractive matter of logwood has not been determined. It is known that the wood contains hæmatoxylin, and it is supposed that certain glucosides are present, which, during the process of curing, are broken up, yielding hæmatoxylin or hæmatein. Hæmatein is produced during this process, as will be shown later. Wood which has been subjected to this treatment, although it contains

from ten to twenty-five per cent. more water, gives the dyer much better results, particularly on wool, than an equal weight of the wood in the condition it comes from the chipping or grinding machines.

For a long time attempts have been made to develop, or increase the dyeing power of the extractive matter of logwood, either during the extraction process, or after the extractive matter had been obtained in an aqueous solution. Most of the substances used for this purpose are oxidizing agents, and are used probably with the idea of converting hæmatoxylin into hæmatein. In 1885, C. E. Avery obtained a United States patent for the oxidizing of logwood liquors or extracts by the action of "oxidants such as a solution of bleaching powder, hypochlorous acid, chloric acid, chlorates or nitrates of the alkalies and alkaline earths." He further claims the use, for this purpose, of "oxidizing substances, such as solutions of chlorates of potash, or lime, or nitrates of potash, soda, or lime, which, whilst mixing with the logwood liquor at moderate temperatures, oxidize slowly or not at all, but on raising the temperature, particularly under pressure, or by the addition of acid or acid salts, become oxidizers of hæmatoxylin to hæmatein." In the specification of this patent, the quantity of a chlorate or nitrate necessary to convert a given quantity of hæmatoxylin is stated, but no directions are given as to the quantity of bleaching powder, or hypochlorous acid to be used to effect the desired result. The authors made many experiments, both following closely the specification of this patent, and with variation of the quantity of oxidants, and of the method of using them, but were not able to obtain any results which would pay for the labor and material used. In using a solution of bleaching powder for this purpose, it was assumed that the combined or available chlorine was the oxidizing agent intended to convert the hæmatoxylin to hæmatein, and although many experiments were tried the result was invariably a dull gray shade of black.

In Wurtz's *Dictionnaire de Chemie* (vol. i, pt. 1, p. 645,) it is stated that chlorine converts hæmatoxylin into a brown

amorphous mass. Erdmann (*Jour. für Prak. Chemie*, **26**, 202), Reim (*Berichte der Deut. Chem. Gesell.*, 1871, p. 329,) and Dralle (*Ber. der D. Chem. Gesell.*, 1884, p. 372), found that no definite and separate compounds were formed by the action of chlorine on hæmatoxylin. After many fruitless experiments, and when all probable means of producing the desired result had been tried, it was determined to make some experiments, using free chlorine, added in the form of an aqueous solution, to the solution of the coloring matter. For this purpose a dilute aqueous solution of the extractive matter of cured wood was used. The results were determined by making dyeing tests in the mixed solutions with skeins of woollen yarn mordanted with potassium dichromate and potassium bitartrate. The results were surprising, and showed that the depth of color increased with the amount of chlorine used, until a maximum quantity was reached, when any further increase in the quantity of chlorine produced a dull and gray shade. After further experiments, it was found that by using a 42° extract of logwood, which had undoubtedly been made from dry cut wood; that is, wood not subjected to the curing process, and chlorine equivalent to about nine per cent. of the weight of the extract, the dyeing power of the coloring matter was increased 150 per cent.

Owing to the difficulties experienced in making and handling large quantities of chlorine water, it was found necessary to devise some other means of treating the extractive matter with the chlorine. Very good results were obtained by circulating the solution of the extractive matter through any suitable vessel, so arranged as to expose as large a surface of the solution as possible, and into this vessel the chlorine gas was delivered from the generator. The quantity of chlorine used was regulated by the quantity of materials placed in the generator. Later, it was found that if, during the absorption of the chlorine, the temperature of the solution was maintained at about 80° C., less chlorine was required to produce the desired result than when the action took place at the ordinary temperature.

It has been stated that by increasing the coloring power

of the logwood by the use of oxidizing substances, the colors obtained are not fast on exposure to light and air. In practice, however, it was found that a sample of worsted cloth dyed black on chromium mordant with logwood extract developed with chlorine, after an exposure of six weeks, had not undergone any more change in shade than a sample dyed with ordinary cured wood.

In order to ascertain the exact chemical change which takes place in the hæmatoxylin in this process, a sample was obtained, manufactured by E. Moerk, and treated in the same manner as the extract. First, to determine the amount of chlorine necessary to yield the greatest dyeing power, samples were treated with varying amounts of chlorine and dye tests made. It was found that the greatest development was obtained when the proportion of chlorine was four atoms to each molecule of hæmatoxylin, which is equal to forty-seven per cent. of the hæmatoxylin. This would indicate a more complex reaction than the conversion of hæmatoxylin to hæmatein, as that would require but two atoms of chlorine for each molecule of hæmatoxylin.

$$C_{16}H_{14}O_6 + Cl_2 = C_{16}H_{12}O_6 + 2\,HCl$$

Avery, in his patent, calculates the amount of oxidizing agents necessary, on the basis of the simple reaction—

$$C_{16}H_{14}O_6 + O = H_2O + C_{16}H_{12}O_6$$

This constitutes a marked difference in the two processes. A larger quantity of chlorine renders the shade dull and gray.

It is stated by various authorities, especially by Dralle (*Berichte*, 1884, Feb., p. 372), that no separable compounds are obtainable by the action of chlorine on hæmatoxylin and that hæmatein is not formed in the reaction. An attempt was made to determine the products of this action and a larger quantity of hæmatoxylin was treated with the proportional amount of chlorine, viz: four atoms of chlorine to each molecule of hæmatoxylin. The method used was to dissolve the hæmatoxylin in hot water, allow it to cool and then treat with chlorine water containing the calculated

amount of chlorine gas. By repeated washing with ether, containing a small portion of alcohol, and distilling off the ether and drying, there was left a brownish, resinous mass, completely soluble in alcohol. By treatment of this residue with chloroform, a white crystalline substance was separated. This was soluble in ether, water, chloroform and acetic acid. However, this was not obtained in sufficient quantity to determine the composition or characteristics. By farther treatment of this residue with ether, two bodies were separated; one with a brownish, resinous appearance, the other with a bright greenish, metallic lustre. By saturation of the original solution with common salt, and again treating with ether, more matter was extracted, but was found to consist mainly of brown, resinous matter. Since this method of saturating the solution with salt to separate the products of this reaction appears to have been used in former investigations, it is probably the cause of the statement that only resinous bodies, not admitting of purification, are the result of the action of chlorine on hæmatoxylin.

By carefully distilling the ether from the washing of the solution, it is possible to separate most of the bronze substance before the solution is completely evaporated, It then separates in shining scales, which are apparently not crystalline. These contain small amounts of the resinous matter. By washing with ether several times, it is possible to obtain a bright greenish bronze body, with a strong metallic lustre. This gives a red, almost approaching violet, powder. Although seemingly pure, it contains a trace of chlorine and has not been obtained sufficiently pure to warrant a determination of the composition by combustion. It is insoluble in cold water, somewhat more soluble in hot water, freely soluble in alcohol, almost insoluble in ether and chloroform. It has powerful dyeing properties, five per cent. on wool giving a blue black. Therefore, in its physical characteristics and chemical properties, it is identical with hæmatein, and justifies the supposition that it is hæmatein. It is hoped to obtain this in a state sufficiently pure to make a determination of the composition.

The resinous substance is easily soluble in ether, alcohol

and water. It appears to be a chlorine substitution product of either hæmatein or hæmatoxylin, as the amount of chlorine contained in mixtures of this and hæmatein is in proportion to the amount of this substance. It remains in the dye bath, after the hæmatein has been absorbed by the wool, and probably has no effect on the color produced. The difficulty in completely separating these bodies lies in the fact that hæmatein is soluble in solutions containing the resinous matter; therefore, it is very difficult to obtain one entirely free from the other.

In order to have some standard of comparison with the coloring matter of logwood after curing, a well-bronzed sample of wood was treated with alcohol. To this solution, which was brownish-yellow, hydrochloric acid was added, and the whole distilled to a small volume. On cooling, there was an abundant separation of coloring matter which, after treatment with ether and alcohol, remained as a bronze powder. A combustion of this was made, which gave—

	Erdmann found
C, 62·94	62·66
H, 4·31	4·16
O, 32·75	33·18

From this it is evident that this is the same as the hæmatein obtained by Erdmann by the oxidation of hæmatoxylin in the presence of ammonia.

On making comparative dye tests of the coloring matter obtained by the action of chlorine on hæmatoxylin and this extracted from cured wood, the colors obtained were very similar in depth and shade; that of the hæmatein from wood being slightly duller. Both were about double the color obtained with hæmatoxylin. With the latter it is very doubtful if any deeper shade than a very light blue would be obtained if the air were entirely excluded from the bath; the shade constantly growing deeper in proportion to the time the dyeing is continued, while with hæmatein the bath is exhausted in a comparatively short time and no farther increase of color occurs.

In practical dyeing there are several methods in use which are radically different; wool dyeing being carried out in a neutral or slightly acid bath at 100° C.; cotton dyeing, commonly in a slightly alkaline solution, and what is known as speck-dyeing, in a strongly alkaline solution containing caustic alkali at a temperature below 15° C. Speck-dye is used to color the cotton in mixed goods after the wool has been dyed, or to color the burrs and other vegetable substances which may have become mixed with the wool. The low temperature is employed to prevent the wool absorbing any color during the operation. From the differing conditions, it was considered probable that varying results would be obtained from the use of the same coloring matter in each of these methods. In the experiment with wool, equal weights of woollen yarn were taken and mordanted with three per cent. potassium dichromate and two per cent. of potassium bitartrate. These skeins were then dyed with five per cent. each of hæmatoxylin, hæmatein from cured wood and hæmatein obtained with chlorine. The operation was carried on at a boil for one hour. The shade given by the two hæmateins was at least twice as full as that obtained from hæmatoxylin. Next some speck-dye was made of the same substances in the following proportions: five per cent. coloring matter, forty-four sodium carbonate, five sodium hydrate, one of sodium sulphite and sixteen of copper sulphate; each dissolved in water, the solutions mixed, made up to equal volumes, boiled and allowed to cool. The skeins of unmordanted cotton yarn of equal weights were then dyed in these baths. In this case the shade obtained with hæmatoxylin was much darker than with the hæmateins; these being of little practical value. There was a marked difference in the appearance of the baths, that of the hæmatoxylin being of a deep purple color, with little or no precipitate, the other two of a blue color, with much precipitate.

Noticing a yellowish color in this precipitate, which might have been due to the reduction of the copper, the action of each of these substances was tried on Fehling's solution. It was reduced by hæmatoxylin much more slowly

than by hæmatein; but it was found that more copper was reduced by the hæmatoxylin than by the hæmatein. Fifty milligrammes of hæmatoxylin gave ·1675 gram Cu_2O, and the same quantity of hæmatein, ·1541 gram Cu_2O. These may not be the constant reduction proportions, as this was not tried under varying conditions; but these figures were obtained by treating the bodies with an excess of Fehling's solution. A farther report will be made on this subject. From these experiments it would appear that when alkaline solutions are used in the application of logwood, the extract or decoction should be made of dry cut wood, while for wool much better results are obtained by the use of cured wood.

On finding that free chlorine in proper proportions would increase the dyeing powers of logwood extract and that an excess produced dull and gray shades similar to those obtained by the use of bleaching powder or calcium hypochlorite, the experiment was tried of reducing the amount of the calcium salt to about half the theoretical quantity. When this was done, a marked increase of color was obtained, with no deterioration in shade. It has been shown that the greatest development of the dyeing power of hæmatoxylin results when forty-seven per cent. of free chlorine is used; but when a solution of bleaching powder is employed, the same effect is produced when the proportion of available chlorine to hæmatoxylin is but twenty-three and one-half per cent.

PHILADELPHIA, January 21, 1890.

NOTES AND COMMENTS.

CHEMISTRY.

CHEMICAL NOTES FROM THE PARIS EXPOSITION.—Prof. Lunge, of Zurich, who was the Swiss member of the jury for Class 45 (Chemical Processes and Products) has published some interesting notes of his observations in the *Zeitschrift für Angewandte Chemie*, from which we make the following extracts:

On the Manufacture of Sulphuric Acid in France.—The Société des Manufactures des Glaces et Produits Chimiques de Saint Gobain, Chauny et Cirey, with six different branches, is the largest establishment of its kind in France. They possess a lead-chamber space of 156,500 cubic metres with fifty-three Gay-Lussac towers and thirty Glover towers, in which 117,000 tons of sulphuric acid (reckoned at 66° B.) are yearly manufactured. They produce daily 4 to 4·5 kilos of actual sulphuric acid (H_2SO_4) per cubic metre of lead-chamber space, with a consumption of one part of sodium nitrate per 100 parts of H_2SO_4. For the concentration of the acid, they have twenty-six platinum stills, valued at over 1,000,000 francs. Of nitric acid they manufactured in 1888, 4,900 tons. They decompose annually 37,000 tons of salt, partly in Mactear ovens, and leave only 0·025 per cent. of iron in the sulphate. The sulphate is partly used as such and partly changed into soda crystals, soda salt and caustic soda.

Potassium sulphate, ferrous sulphate and superphosphates, are also manufactured on a large scale. The establishment has just introduced Chance's sulphur regenerative process with perfect satisfaction, which, however, was attended with some difficulties at first, as the character of the soda residues in France differs somewhat from that of the English residues.

Recognition of Chance's Sulphur Regenerative Process.—The jury, which included such eminent French technologists as Scheurer-Kestner, Kolb, Leguin (from St. Gobain), Knieder (from Malétra), Frémy and Schloesing by a unanimous vote awarded the *Grand Prix* to Chance's process. This has now been successfully operated at the works of Messrs. Chance, at Oldbury, for the past year and a half, and has been introduced or is being introduced under license of the inventor into almost all the large English soda works.

Ammonia-Soda.—The ammonia-soda process was especially represented at the Exposition by the great firm of Solvay & Co., who had erected a special pavilion as part of the Belgian exhibit. Beside this, the firm exhibited in the French section, and the affiliated firms of Brunner, Mond & Co. in the English section and the Solvay Process Company in the American section had special displays. These several firms, together with the works of Solvay & Co. in Germany, Austria and Russia, produce annually the enormous amount of 400,000 tons of soda, which is almost the half of the entire soda production of the world. The introduction of the ammonia-soda process, with which Solvay's name is especially connected, has been the

chief element in cheapening the price of this indispensable product of chemical industry. The saving to mankind thereby can be estimated at 100,000,000 francs annually. A special merit of the ammonia-soda process is that its manufacture is not like that of Leblanc soda, locally defined because of economic reasons, as it uses so much less coal in its production. While England was formerly almost the only country exporting soda and Germany, America and Russia were dependent upon English soda, now each of the larger countries can produce its own soda and have, in fact, become in large part independent.

Manufacture of Chlorates by Electrolysis.—The process of Gall and Montlaur (English Patent, No. 4,686, of 1887), which is already in operation on a manufacturing scale at Villers-sur-Hermes (Oise) and soon to be started on a larger scale at Vallorbe, in Switzerland, attracted the attention of Prof. Lunge. The decomposition of the alkaline chloride by electrolysis takes place at such a temperature that the hypochlorite is decomposed, as fast as formed, into chlorate:

$$6\,KCl + 3\,H_2O = K\,ClO_3 + 5\,KCl + 6\,H.$$

The reaction is carried out in apparatus provided with diaphragms, the special construction of which is not made public. The potassium chlorate crystallizes out as it forms, and is scooped out with enamelled iron spoons. The electric current used has a strength of 1,000 ampères and an intensity of twenty-five volts, so arranged that the electro-motive force in each bath is about five volts (the theory demanding 4·35). In practice one horse-power for twenty-four hours is needed to produce one kilo of potassium chlorate. With abundant water-power, this power can be had cheaply, but if dependent upon steam exclusively, it would not be sufficiently economical. At present the production of one kilo of potassium chlorate requires, even under favorable conditions, the consumption of twenty-five times its weight of coal.

S. P. S.

ENGINEERING.

ONE BY ONE the great engineering works of the ante-railroad days are being eliminated from the field of competition with railroads as common carriers. Only recently, the Pennsylvania canal was absorbed and portions of it converted into a roadbed for rails. Now it is seriously contemplated to subject the Chesapeake and Ohio Canal to a similar process, and it is frequently asked what is to become of the Delaware and Raritan Canal since it no longer pays?

The more pertinent question would seem to be: Why does it not pay, when, even under the best conditions, the cost of movement by rail is greater than that by canal? Why should the latter be permitted to fall into decadence and the bulky freights be diverted from their cheaper lines of transportation to the more expensive ones at greater cost to the companies handling them and to the public? The net earning capacity of the Delaware and Raritan is shown by its balance-sheet during its palmy days to have been over

$900,000 in one year before its lease to the railroads, and the cost of movement, as shown by the tariff charges, was only about one-half of the present rates. By increasing the depth and enlarging the capacity of these artificial water-ways, the cost of the movement may be still further greatly reduced, the value of a navigable channel varying as the cube of the depth. The rapidly developing interests in ship canals is an evidence that the importance of movement in bulk by water is becoming more fully appreciated. It is now time that the Delaware and Raritan Canal should be put on this basis.

L. M. H.

BOOK NOTICES.

THE COLLECTION OF BUILDING AND ORNAMENTAL STONES IN THE UNITED STATES NATIONAL MUSEUM. A handbook and catalogue. By Geo. P. Merrill. Washington. 1889.

This book's title is attractive and the subject it treats most interesting, but it is less than the public has a right to expect in several particulars.

In the prefatory note we are informed that the collection of specimen rocks in the National Museum is "made up from materials received from the Centennial Exposition at Philadelphia, in 1876, and from the Tenth Census at the close of the investigation of the quarrying industries in 1880. By far the greater and more systematic portion of the collection is from the latter source," etc.

How systematic this is, we learn from the fact, "In preparing the exhibit the stones have been arranged by states, and under states by kind; this method seeming best adapted to the wants of the general public."

A less systematic and more completely unscientific method of arrangement could not be devised, but Mr. Merrill is doubtless right when he says that it is best adapted to the wants of the public. Each man or woman of the Washington public (by which in all such cases is meant the floating population, whose trade is statesmanship), with few exceptions, desires to see "the rocks they raise down our way," and to compare the number of tons of exhibit from his state with the number of tons from its greatest rival.

The arrangement of the birds mammals, and shells of this country in the National Museum by states means the absence of a rational taxonomy. It is the device of a state fair which arranges its poultry, butter and pippins by counties; a method by which the least important county often has the handsomest exhibit. But passing this by as an *ad captandum* measure, whereby a collection is confused for scientific study for the purpose of popularizing appropriations for geological surveys, there are other and greater faults in the volume.

Among these may be mentioned the capriciousness with which the authorities for the various statistics are mentioned. Many instances occur in the volume where either the work of years has been summarily and imperfectly condensed and "edited," or the information has been gleaned by some

person, who, owing either to insufficient time or experience, has not properly made a digest of it.

This kind of defect is common to many of the most valuable scientific publications which come from Washington. It seems impossible for a man to live in that atmosphere, whatever his occupation, without becoming a partisan and assuming to himself the function of deciding who of the inferior masses who toil elsewhere, shall, and who shall not enjoy such immortality as recognition by Washington placemen can confer. In spite of its defects, however, the volume will have value to those who are not required to form a distinct notion of the comparative importance of the rocks described, or of the sources of the completest information concerning them outside of the United States and its allied State surveys. F.

REVIEW OF WRIGHT'S ICE AGE IN NORTH AMERICA. By Prof. C. H. Hitchcock, Dartmouth College, Hanover, N. H. Bibliotheca Sacra. January, 1890.

This article, in the form of a review, from one of the masters of geological science in our country, is replete with information bearing on the general topic of glaciation and might well be made an historical introduction to that branch of superficial geology. The turning point in the thought of at least the English-speaking races upon the subject of glaciation is rightly ascribed to the "Great Ice Age," by Prof. James Geikie, now Professor of Geology in the University of Edinburgh. Shortly after the appearance of this book, the Rev. G. F. Wright, with the late Prof. H. Carvill Lewis commenced the study of some of the phenomena connected with the ice age in America and especially of the boundary of the terminal moraine which they traced through New Jersey, Pennsylvania, Ohio, Kentucky and Indiana. The summer of 1886 he spent in Alaska upon the Muir Glacier. "This glacier is located at the head of Glacier Bay, in latitude 58° 50′ and longitude 136° 60′, with mountains over 15,000 feet high, between itself and the Pacific Ocean. The glacier is formed of nine branches and seventeen branchlets which discharge into the inlet from a point of 300 feet." The rate of progress was forty feet per day on the sides and seventy feet in the middle. The water front of the ice is about one mile and bergs are falling off as frequently as every ten minutes.

The eras of progress of the ice question are placed: (1) From 1800 to 1860, when the belief was almost general in the submergence of the continent and the action of icebergs. (2) 1860 to 1880 when the iceberg theory gradually gave place to that of the existence of glaciers of much greater dimensions. (3) The last ten years when all previous theories of superficial geology have been found too superficial and have been remodelled.

The elder Prof. Edward Hitchcock's early contributions to the glacial theory are well and modestly attended to. Prof. C. H. Hitchcock considers the upshot of the Niagara Falls discussion to be that the gorge is 7,000 years old, and that this time has elapsed since the ice melted away from the Lewiston escarpment. Prof. Prestwich thinks the entire period of cold may not

have exceeded 15,000 to 25,000 years. Thus the whole Quaternary period (to date) may be reduced to 36,000 years.

The question of the antiquity of man is concerned in this discussion. Most of the relics of man found in this country had their origin subsequent to the later ice period (if there were two), *i. e.*, less than 7,000 years. Quite recently, geologists are returning to the belief that the crust of the earth is comparatively thin over a molten interior, and also that the surface is sensitive to deformation by weight and pressure. The transference of a single foot of sediment from the upper to the lower part of an hydrographic basin is thought to change the level, owing to the disturbance of the equilibrium.

The little treatise concludes with some excellent advice to those ministers of the Gospel who can spend time in travel, hunting or fishing, to devote their time to the study of glaciation and its attendant phenomena which, while resulting in good to the world, will give them a better idea of the phenomena, the effort to understand which too many of them take to be an assault on the defences of "the true faith." F.

REPORT OF PROF. T. C. MENDENHALL, Superintendent U. S. Coast and Geodetic Survey, to the Secretary of State.

This is a bulletin of eight pages in pamphlet quarto, giving a succinct account of what has been done up to the present time in regard to the unification of weights and measures throughout the world. It does not give any summary of the populations which use the metric and other systems, but a few tables of the nations on this continent using the metric system. From this it appears that among 36,000,000, more or less, forming ten nations on this continent, to-wit, the Argentine Republic, Brazil, Colombia, Costa Rica, Ecuador, French and Dutch Guiana, Mexico, Peru, Uruguay and Venezuela, the use of the system is obligatory. In Bolivia, Guatemala, Hayti, Honduras, Paraguay, it is partially in use or legalized. In British Guiana, Salvador and San Domingo, other systems are in use. To the second class both Canada and the United States should be added. It concludes with recommendations to Congress to recommend the advisability of promoting uniformity among nations; that the decimal system form the basis of unification; that all nations not now parties to the convention signed in Paris, in 1875, become so; that the aggregate statistics of international commerce be published in metric equivalents; that all invoices shall be made out in metric weights and measures; that metric weights and measures be used exclusively in the mints.

The recommendations are timely and just. It is inconceivable that England and the United States, which claim to be in the van of civilization and progress, should still refuse to see that unification is inevitable, and that an international standard is a step in the direction of economy and of education. The legislatures of both these great countries have on several occasions come within a few votes of adopting the system, and thus establishing uniformity throughout the world. The only great nation which still holds out besides these two is Russia, and her system is to a certain extent, "aliquotted" to

the metric system. It is not generally known that England has for many years adopted the metric system for her Indian possessions, although the names employed are not those of that system. Why cannot our country make this great and useful reform? F.

COLLECTION OF APPLIANCES AND APPARATUS FOR THE PREVENTION OF ACCIDENTS IN FACTORIES. (42 plates.) With explanatory text in French, German and English. Price, 8 shillings. Mulhouse: H. Stückelberger (late Detloff), publisher. 1889.

"The manufacturer owes his workmen other things besides merely their wages," (quoting the words of Mr. Dollfus, given at a meeting of the Industrial Society of Mulhouse, in February, 1867). Among these may surely be named, personal safety, secured from the moment they enter his service. To argue the need of such care-taking would be as throwing words away, and whatever may be said for or against the objects and aims of the society, it has lived to see its labors crowned with success; therefore, they may consistently ask others to contribute to this extraordinary and benevolent work.

To ask for assistance in whatever way it can be given to save the limb and life of a fellow creature, while engaged in winning bread and in doing his part of the world's work is always an unquestioned duty.

This assemblage of appliances and apparatus, proves on examination to be a veritable encyclopædia of ingenious and practical means for the prevention of accidents in factories, and of injury to the operatives working therein; it embodies the full record so far as completed by this committee, up to the year 1889, covering twenty years of active existence.

This committee has gone further than the perfection and introduction of its many ingenious and effective safety devices within the boundaries of its own localities, which it has accomplished through a well-directed effort in the adoption of its inventions by publishing an atlas, comprising forty-two double plates, each crowded with numerous well executed and definitely drawn details, which explicitly show the devices so far as known, where applied to each machine or part thereof, and in what manner it protects the operative from harm. To these illustrations is added a tri-lingual description, thus enabling the French, the German and the English reader to know all about them, and to fully understand their construction and application.

The self-appointed task assumed by this committee having already accomplished remarkable results, seeks, by a well-directed public spirit, through this publication to diffuse them among manufacturers everywhere. This publication is, therefore, recommended to the attention of all those who take more interest in the manufacturing problems of the day than in the mere mercenary outcome of them.

In furtherance of the grand objects contemplated and in great part completed, this committee conducts well organized inspections of factories; seeks to popularize the appliances of those made within or invented and introduced by members outside its own environments; by publications and interchange of correspondence of every kind; by the co-operation of others who might assist in this benevolent work and finally by offering prizes to those who

desire something new and useful in this line—and strange to say, the first prize awarded by the association was given to a child—an operative.

To further widen this new field of usefulness, if such were possible, to encourage the development of thought and invention in this noteworthy direction, a number of model frames were built, each provided with working examples of illustrative safety appliances which were placed and exhibited in the largest towns of Europe.

We are surprised and pleased to find on search, and to repeat, if the reader does not mind a few figures, that hundreds of thousands of francs have already been expended by this association, merely in technical researches for the invention of safety appliances in addition to which it inspects 1,027 industrial establishments employing more than 80,000 hands.

An outline of the subjects treated in this work by which the reader will get a measured idea of its scope, includes the following leading details which are noted here, rather as heads, the amplifications of which, in varied forms, are well filled out on its pages.

Railings and casings around and about fly-wheels and the moving parts of motor engines, particularly the enclosing of cranks and connecting rods. Hand clearance among moving parts for safety in the act of oiling them, even body-room under large cranks, we well know, would have saved lives. The shielding of gears, the application of safety tubes to piston-rods and the like, when they run out the back cylinder-head.

Means for the sudden stoppage of motors from any desired point in a workshop, thus avoiding very serious accidents; on the other hand, devices for preventing the unexpected starting of machinery while adjustments or repairs are being made.

Ladders built firm and strong, safe to mount and impossible to slip on any floor.

Projecting screws and keys to be shielded against catching the garments of operatives who are required to work near them.

Devices for shifting belt, with safety to the operator, and of holding them from winding on their shafts or becoming entangled with projecting parts, or getting wedged in narrow places.

A fruitful source of accidents is from the various kinds of hoisting machines, the greater need therefore for safety catches for preventing the cage from falling from any cause whatever, and of railing around the hatches and protecting doors at all the landings to prevent accidents when the cage is not there. The committee says: "It is, nevertheless, imperative to pay due attention to the best methods of construction of the lifts themselves."

This remark lies directly in the line of good and safe engineering. It may be treason to say it, but the building and buying of carelessly and cheaply made lifts is a crime.

Numerous examples of safety devices are given in relation to hoisting mechanism; so also as to circular saws and other high speeded wood-working machines.

Liberal reference is made to the use of tongs, sliding bench-vises and other convenient and guided holdfasts, extensions of human hands, so to

speak, by which the latter never near the point of danger, and are by these judicious means, protected from injury.

A multitude of devices are figured for securing safety about the machines employed in the textile industries in printing and dyeing establishments, about grinding mills, grindstones and steam boilers.

The mere mention here made of subjects treated, many of which are familiar to us, gives no idea whatever of the fulness and variety of the illustrations on these pages, each one is like a word defined in the *New Century Dictionary*, where examples are expected an exhaustive treatise is given.

We should be encouraged by the humanitarian aim and accomplished results of this committee to solicit the good-will at least of factory managers, professors, mechanical engineers and manufacturers.

Valuable aid to and enlargement of this work could be had by decreeing that the curriculum of technical colleges should include the study of safety appliances for the prevention of accidents. J. H. C.

GIFTS TO THE LIBRARY OF THE FRANKLIN INSTITUTE.

Académie des Sciences, Belles-lettres et Arts de Lyon. Mémoires. Vols. 29 and 30. From the Société d'Agriculture de Lyon.

Academie Royale de Belgique. Annuaire. 1890. From the Academy.

Ætna Powder Company. Descriptive Pamphlets. From the Company.

Agricultural and Mechanical College, Alabama. Bulletin No. 7 of the Agricultural Experiment Station. From the Station.

Agricultural Experiment Station. Auburn, Ala. Bulletin No. 9 and 10. From the Station.

Almanaque Nautico, para 1891. From El Instituto y Observatorio de Marina.

American Bankers' Association. Resolution of Executive Council. From William H. Rhawn.

American Institute of Mining Engineers:

Transactions. Vol. 17.

Blow. The Geology and Ore-Deposits of Iron Hill, Leadville, Colorado.

Chauvenet. The Iron Resources of Colorado.

Goodale. Notes on the Additional Diaphragm in the Howell Roasting Furnace.

Schwarz. The Ore-Deposits of Red Mountain, Ouray County, Colorado.

Ashburner. The Coal Trade and Miners' Wages in the United States for the Year 1888.

Olmsted. The Distribution of Phosphorus in the Hudson River Carbonates.

American Institute of Mining Engineers:

Firmstone. Note on the Form of Crater Produced by Exploding Gunpowder in a Homogeneous Solid.

Dudley. The Wear of Rails as Related to their Section.

Keep. Aluminium in Cast Iron.

Proceedings of the Fifty-fifth Meeting, Ottawa, Ont., October, 1889.

Gilpin. The Geological Relations of the Principal Nova Scotia Minerals.

Randolph. Notes on the Republic of Colombia, S. A.

Raymond. Biographical Notice of William H. Scranton.

Newberry. Notes on the Geology of the Aspen Mining District.

From the Institute.

American Iron and Steel Association. Revision of Tariff.

From the Association.

American Pharmaceutical Association. Proceedings at the Thirty-seventh Annual Meeting. From the Association.

American Society of Mechanical Engineers. Transactions., Vol. 10.

From the Society.

Ammen, Daniel. Certainty of the Nicaragua Canal.

Errors and Fallacies of the Inter-Oceanic Transit Question.

Instructions to Rear-Admiral Daniel Ammen.

From the Author.

Anderson's Revolving Purifier. Description. From E. Devonshire.

Baird, John. Model of the Centennial Exhibition. From the Author.

Bee-Keeper's Supplies and Bees. Illustrated Catalogue.

From A. G. Hill.

Brassart Fratelli. Catalogo Descrittivo degli Strumenti di Meteorologia.

From the Firm.

Cabble Excelsior Wire Manufacturing Company. Illustrated Catalogue.

From the Company.

Canada. Tables of the Trade and Navigation of the Dominion of Canada.

From Customs Department.

Franklin Institute.

[*Proceedings of the Stated Meeting, held Wednesday, February 19, 1890.*]

HALL OF THE FRANKLIN INSTITUTE,
WEDNESDAY, February 19, 1890.

JOSEPH M. WILSON, President, in the Chair.

Present, 126 members and thirteen visitors.

Additions to membership since last meeting, seventeen.

The President made a statement concerning the importance of continuing the efforts which were so successful during the previous year in increas-